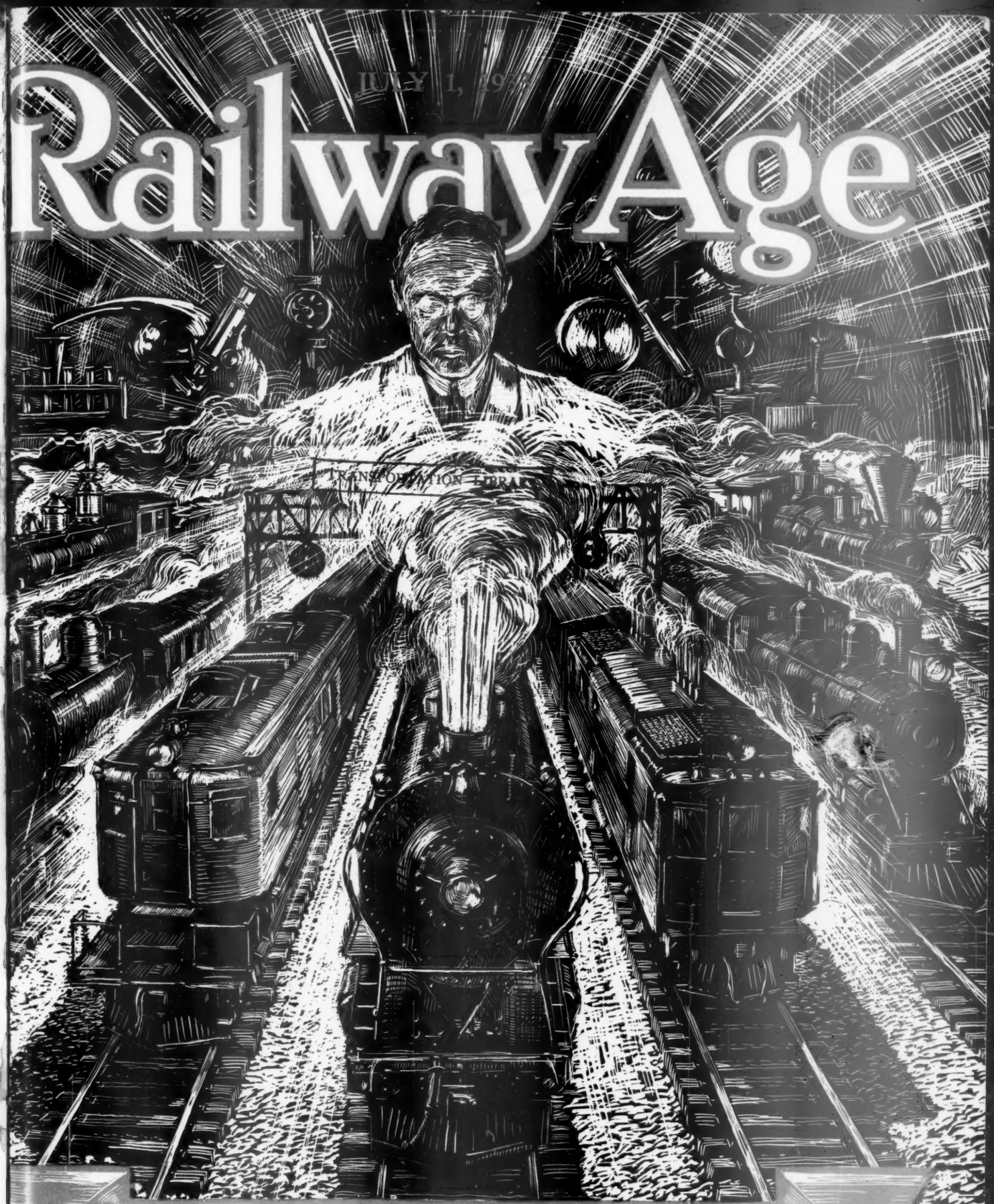
JULY 1, 1933

Railway Age



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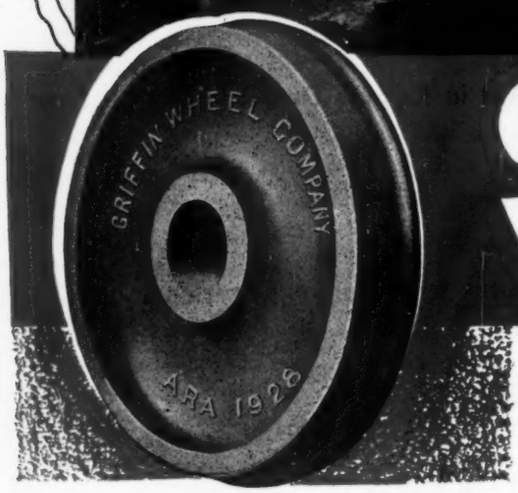

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RAILWAY AGE

The Future of the Railways

The "Century of Progress" which is being celebrated with a great world's fair in Chicago would have been impossible without a century of progress in railroad transportation. There is hardly any form of progress illustrated by that fair which could have occurred without the coincidental development of the railroads. Almost throughout the last one hundred years railroad development largely determined the nation's economic development. The railroads of this continent were the first to adopt the methods of mass production, and their introduction of these methods has made it possible for our other industries to lead the world in mass production. Much of the technical development in other industries has been based upon previous successful efforts to improve the structures and equipment of the railroads. Without the spreading of the railroad net it would have been impossible to have welded the United States into a single political and commercial unit. Without it the creation of a homogeneous social life over such a vast area would have been impossible. The economic, political, mental and social standardization of the nation, whatever its merits or demerits, has been principally caused by the free exchange of goods, the speed of communication and the ease of travel which the railroad alone long made possible.

Transportation in a Condition of Flux

While we are celebrating a century's progress to which the railroad contributed more than any other agency, we are entering another century the developments in which are as uncertain as in 1833 were those that would occur during the century now ended. Every circumstance of our lives seems to be in a state of flux which appears to be the forerunner of as great changes in our economic, political and social life as those which were beginning one hundred years ago. We are emerging from a depression as a result of which the federal government, with the acquiescence, if not with the approval, of all classes of the people, is beginning to exercise an amount of supervision over every branch of production, commerce and finance which would have been absolutely inconceivable a century ago to our people, who then wanted nothing so much from their government as the freedom to lead their lives and achieve their fortunes in whatever way they saw fit.

Probably no other industry is now in more of a condition of flux than the transportation industry, the development of which was just commencing at the beginning of the century of progress now being celebrated. The railroad industry, which did more to make the last century of progress possible than any other, is being subjected to more government control of its earnings and operating expenses than any other, and is just beginning to be subjected by government to a new form of co-ordination for the purpose of reducing the competition within itself which, during almost one-half of the last one hundred years, it was an important purpose of government policy to maintain and intensify. While the government is exercising such various forms of control over the railways for the purpose, among others, of reducing competition between them, it is continuing to subsidize other carriers without regulating them, with the result of enabling them to increase the effectiveness of their competition with the railroads.

It is natural that, under such conditions, many persons should be raising a question as to whether the railways have any future, and if so, as to what it is going to be.

Railroad Research and Development Work

The American Society of Mechanical Engineers decided to devote one of the meetings of its railroad section this year to railroad research, being influenced to do so largely by the fact that recently there has been criticism of the railroads for lack of progressiveness, and that this lack of progressiveness has been attributed to a lack of research on their behalf. The popular conception of research is something that is done by scientists in a laboratory. The purpose of every kind of research done for an industry, however, is to promote some kind of development in the industry. It may be research, whether done in a laboratory, or by observing

the performance of a loaded train on a track, and as a practical matter it is often difficult to say where research ends and development begins.

The papers presented during the railroad research session of the American Society of Mechanical Engineers this week, and which are published in part or in full elsewhere in this issue of the *Railway Age,* tell a very impressive story of the vast amount of research and development work that has been done for the railroads by the railroads themselves, by the manufacturing industry and by leading universities. These papers are supplemented in this issue by articles prepared by members of the *Railway Age's* editorial staff regarding some kinds of research and development work done for the railroads that were referred to only in a general way at the meeting of the American Society of Mechanical Engineers.

The papers and articles, together with information given by manufacturers in the advertising pages of this issue, constitute a comprehensive and impressive refutation of the propaganda that has been spread abroad to the effect that a lack of progressiveness has been shown in doing the work necessary to enable the railways to meet modern transportation demands. They show that railway safety, efficiency and economy have been constantly increased; and that every major improvement in methods of operation has been made possible by, and has been based upon, some of the major physical improvements, or the accumulated effect of numerous minor physical improvements, which have resulted from the research and development work that is outlined in this issue.

Will Railroad Progress Be Continued?

The record already made by the railroads in increasing safety, efficiency and economy will bear searching scrutiny. Will equal progress in railroading be made in future? If so, how will it be made? It can be answered confidently that the record of progress will be maintained if opportunity is afforded. The reason why this answer may be confidently made is that, as the contents of this issue of the *Railway Age* shows, railway officers are still looking in every direction for means of improving railway physical properties and methods, and that never was there a time when manufacturers were prepared to furnish them so many improvements in equipment and materials that already have been developed or that are in process of development.

It is undoubtedly true that within recent years railway plants, methods and service have not been adjusted rapidly enough to changes in conditions, and especially to changes caused by the development of competing means of transportation, but a very important fact which critics of the railways overlook is that these changes have been so rapid and unprecedented that it would have required more than human foresight to have anticipated them and adjusted railway plants and methods to them as they were occurring. The present period of rapid changes affecting the railways has now lasted long enough to make it possible to appraise both the causes and the effects of many of the changes. The great increase in competition with the railways has been largely due to the favoritism shown by the federal and state governments for competing carriers. This favoritism already is being reduced, and there seems to be reason to hope that it will be further reduced, by new state and federal legislation. Much of the effectiveness of the new competition, however, as is being recognized by railway officers and railway equipment and supply manufacturers, is due to characteristics of highway transportation which render it necessary to meet it with new kinds of railway facilities and methods, and new kinds of facilities are being made available to the railways, and undoubtedly will be acquired and placed in service by them as rapidly as railroad earnings and credit make it practicable.

The Problem of Financing Progress

Will railway earnings and credit become sufficient to finance the needed improvements? This question was being asked a decade ago, and since then about six billion dollars of new capital have been invested in the railways. The improvement in general business and the increase of traffic that are now occurring will, if they continue, as seems probable, rapidly solve the financial problem of the railroads, if public sentiment and government will allow them to make their wages low enough and their rates high enough to reestablish and maintain a reasonable margin between earnings and operating expenses. The only other solution of the railroad problem, if it can be called a solution, is government ownership, and the public and public men seem much more disposed to favor solution of it by making it possible for private management to function successfully than to assume the risks of government ownership.

With general business improving, railroad freight business and earnings increasing, railway managements and equipment and supply manufacturers alive to what must be done to adjust railway facilities, costs and service to new conditions, and public sentiment favorable to the railways, there seems good reason for believing that we are entering a new era of development and progress in railroad transportation.

The Cover on This Issue

Otto Kuhler, who designed the cover of this issue, is recognized as one of America's foremost industrial artists. An engineer by training, an artist by instinct, he has been able to dramatize industry with a sympathetic understanding. His special interest in railroads has provided the inspiration for a number of fine etchings and lithographs, some of which have appeared in *Railway Age.* From such a background has come the idea, portrayed on the cover of this issue, of what research and development have contributed to railway progress.

Researches by Many Agencies Aid in Railway Development

American Society of Mechanical Engineers reviews the projects of the railways, manufacturers and universities on which 40 years of technical progress have been built

THE contribution of research to railway progress was the theme of the program at the Railroad Division sessions of the spring meeting of the American Society of Mechanical Engineers held at Chicago during Engineering Week at the Century of Progress Exposition, June 25 to July 1. The Railroad Division sessions were held Monday, June 26. L. A. Downs, president, Illinois Central, presided during the morning session which was opened with an address by R. H. Aishton, chairman, American Railway Association. The program was prepared under the direction of L. K. Sillcox, vice-president, New York Air Brake Company, chairman of the executive committee of the Society's Railroad Division, and W. H. Winterrowd, vice-president, Lima Locomotive Works, Inc., chairman of the Meetings and Papers Sub-committee.

In opening the meeting Mr. Downs referred to the criticisms of the railways for lack of research which appear in the public press from time to time, particularly those coming from the automotive industry. "Well informed criticism," he said, "is a good thing, and the men who manage railroads are deserving of just as much of it as the men who are engaged in other kinds of business. This criticism, however, is not well informed.

"Many of these improvements, especially those made in railway locomotives, are things that the general public never comes to appreciate. There is a logical explanation of that. It is necessary for a large part of our population to know something about the mechanics of an automobile, but it is necessary for only a small part of our population to know anything about the mechanics of a locomotive. The same is true of their respective markets. There are millions of automobile buyers; there is only a handful of locomotive buyers.

"It has been only a few years since it was necessary to change locomotives on passenger trains every 100 or 150 miles. We formerly used four engines to haul every one of our passenger trains between Chicago and Memphis, Tenn., a distance of a little more than 500 miles. Now we use only one and have less trouble with one than we used to have with four.

"There is every bit as much difference between a modern locomotive and the kind that was built 15 years ago as there is between the motor of a 1933 model automobile and the motor of a 1918 model.

"The same is true of the comparison between the body of the automobile and the cars in which railroad passengers ride. Both are more comfortable. Both are safer. Both are cleaner. Both are more convenient. Both are improved in appearance. One of the greatest improvements of modern times is now being applied to railroad passenger service. That is air-conditioning. The automobile has nothing to compare with it."

Following Mr. Aishton's address, papers were presented by Col. C. D. Young, vice-president, Pennsylvania Railroad, on research conducted by the railroads; by Samuel O. Dunn, chairman of the board, Simmons-Boardman Publishing Company, and editor, *Railway Age*, on research conducted by industries; by Professor G. A. Young of Purdue University and by Professors E. C. Schmidt and Everett G. Young of the University of Illinois, reviewing the extensive research projects which have been conducted at these institutions on railway technological problems.

During the afternoon session Roy V. Wright, managing editor, *Railway Age*, presided. This session was devoted to short discussions of the contributions of research to specific motive-power and rolling-stock developments. Abstracts of these papers and discussions appear in succeeding articles.

Address by R. H. Aishton*

Since your society was organized fifty years ago, the transportation demands of the country had multiplied by 1929 until they were ten times as great as in 1879. During that fifty-year period the population increased 150 per cent but, and this is important, the average rail transportation demand per individual increased four-fold. In other words, every man, woman and child in the United States needed four times as much rail transportation under the conditions of 1929 as they did fifty years previously, so that the measure of increase in population does not by any means indicate the measure of increase in transportation.

You are familiar with the expansion of facilities during that half century, applying not only to length of line, which increased from 93,700 to 249,000 miles, but to the total number of equipment units and the effective performance capacity of each unit. In this development the members of your profession, through the mechanical improvements which they have been able to develop, have played a prominent part, and it is on you gentlemen, your scientific ability, that the railroads must continue to depend for that part of their future development. It is this co-ordinated effort and co-operative spirit that has produced so many refinements in rail service in the last decade.

A recently compiled summary shows that the railroads in the last fifteen years have attacked collectively more than three thousand problems dealing with operating and mechanical practices and construction standards. Of equal importance to this co-operative work is the research work being conducted either by the individual railroads through their own laboratories and organizations or by manufacturers constantly working to develop better means and methods.

In view of all these activities and, furthermore, the results attained therefrom, it cannot in fairness and truth be said that the railroads have been remiss either

* Chairman, American Railway Association.

in research and investigation or in their lack of application of the results of this research to their operating conditions.

Ofttimes the eye serves as a better medium for impressing information on the mind than does the spoken word, so if there is any doubt in the mind of anyone as to just what has been accomplished by the railroads in this direction, may I suggest that a few hours be spent in the transportation exhibit at the Century of Progress exhibition now under way in this great city. That exhibit will indicate the marvelous strides that have been made by the railways of this country in the progressive and scientific development of the transportation machine. They may well point with pride to their accomplishments.

You have heard a great deal about the elimination of waste as applied to the railroads. I doubt if there is a single activity in connection with the railroads where there has not been the most effective action in elimination of waste, and all of it has been put under the microscope of investigating and responsible eyes with a view to its elimination.

It is hard to pick out individual items, but taking the unit costs of railway operation as a basis, if the business of 1929 had been handled on the operating unit costs of 1920 the railway operating expenses in 1929 would have been greater than they were by $1,212,000,000. Somebody will say that is comparing with government operation. All right, let us take 1923 and apply the same figures. If 1929 had been operated on the same unit cost as 1923, operating expenses would have been greater than they were by $521,003,000.

I don't want to create the idea that there isn't an opportunity for cutting of costs. There is, and there always will be. But when anybody tells you that the railroads and their kindred industries are antiquated and out of date and have not taken advantage of their opportunities, you can go to this record and tell them and you can challenge any other industry to show the same amount of progress. The facts, as shown by the record, are quite the reverse. The railways are required by law to produce adequate, safe and efficient service. They are producing such services to the best of their ability and will continue to do so as long as they are in existence. Never before in their history have they applied themselves more scientifically to that task.

For several years the railway industry has with difficulty kept its head above the rising tide of economic and financial problems. I assert without hesitation that more efficient and economical operation, the result of research and mechanical improvement, is all that has saved the railways from extinction during this period. In the future, I look for further improvements in mechanical methods, and believe that these will be a large factor in bringing the carriers back to a normal basis.

Research in Many Industries Underlies Railway Development

Extensive work by the manufacturers has proved an important factor in greatly increased economy and safety of railway operation

By Samuel O. Dunn

Editor, Railway Age, and Chairman, Simmons-Boardman Publishing Company

THE criticism that there is less research and development work done for the railroads than for manufacturers is in a measure an indictment of a large part of the manufacturing industry itself, because the railroads, being a transportation industry, always have bought most of their equipment and materials from manufacturers. Many of the companies which manufacture for the railroads also manufacture for other industries. Does it seem probable that a great electrical or steel company, which manufactures for both the automobile and the railroad industries, would show great initiative and resourcefulness in contributing to the progress of the one, and a conspicuous lack of the same qualities in contributing to the progress of the other? It may be replied that the trouble is that the engineers and managers of railways are themselves less fertile in developing new machinery and materials than those of other industries, and less hospitable to those offered by manufacturers. But the real test of the value of research and development work is the results to which they lead. Let us, therefore, review briefly some of the actual results gained by research and development work for the railways, before surveying the contribution that has been made to that work by manufacturers.

Railroad operation is necessarily hazardous, and one measure of progress in it is the results gained by efforts to increase safety. The number of employees killed in 1913 was one for each 498 employees. Ten years later, in 1923, the number killed was one for each 894 employees, and, in 1931, it was one for each 1,907 employees. In 1931, railroad equipment, measured by fatal accidents, was less than one-half as hazardous as in 1923 and only one-fourth as hazardous as in 1913.

The number of passengers killed in 1913 was one for each 3,000,000 carried. In 1923, it was one for each 7,216,000 carried. In 1931, it was one for each 13,100,000 carried. In other words, travel by rail in 1931 was only about one-half as hazardous as in 1923 and less than one-fourth as hazardous as in 1913. Probably never in history did any other industry make a record in increasing the safety of its operations equal to that made by the railways of the United States within the last twenty years. Such records cannot be made without real research work of the most thorough kind, and the use of the information gained as a guide in effecting extensive improvements.

The investment in the railroads (all roads) increased from $8,938,000,000 in the year ended on June 30, 1893,

a year of prosperity, to $24,885,000,000 (Class I roads) in 1929, or 178 per cent. The number of their employees increased from 874,000 to 1,661,000, or 90 per cent. The increased investment was made both to increase capacity and effect economies in operation, and because the investment in plant increased relatively so much more than the number of employees, each employee in 1929 had machinery to help him produce transportation that had cost almost 50 per cent more than the machinery that each employee had to help him produce transportation in 1893. Traffic units* increased from 136,000,000,000 to 541,000,000,000, or 300 per cent, and the number of units handled per dollar of investment increased from 15.25 in 1893 to 21.75 in 1929, or 42½ per cent; while the number of units of traffic handled per employee, with the aid of more and better machinery, increased from 155,993 to 325,462, or 108 per cent. If the railroads had been operated with the same kind of plants and methods in 1929 as in 1893, they would have required 3,146,800 employees to have handled in 1929 the traffic which actually was handled with 1,661,000 employees and their payroll—based on the average wage paid in 1929—would have been more than $6,000,000,000, instead of being actually less than $3,000,000,000. The increase in the efficiency of plant and methods not only greatly increased average output per dollar of investment and per employee, but made it possible largely to reduce working hours per employee while increasing output per employee.

The saving made in 1929 alone in the fuel bill, due to the increase in the efficiency of its use that had been effected since 1920, was $91,300,000, and the saving made in the fuel bill in the twelve years ending with 1932, due to the increase in the efficiency of its use, amounted to almost $630,000,000.

The improvements in railway service and the economies in operation that have been effected year after year have been due to the co-operative efforts of the managements of the railways and of the companies manufacturing equipment and supplies for them, and the contribution to the art of railroad transportation made by manufacturers in North America unquestionably has been larger than in any other part of the world. The reason for this is that in no other part of the world have the railroads done so little manufacturing for themselves, because almost throughout the first century of railroad development practically all the capital the railroad companies of North America could raise was required for the expansion and improvement of their lines to enable them to keep abreast of a growth of traffic unparalleled elsewhere, which afforded an unequalled opportunity for the development of an industry devoted to manufacturing for railways.

No better evidence that research and development work for the railroads has continued unabated to the present could be afforded than the fact that there has been so much improvement made in the steam locomotive within the last decade that if all the locomotives now in existence in this country were as good as the best, there could be effected, when traffic increases to normal, savings in annual operating expenses far greater than ever have been effected within any past decade.

Because steam locomotives have been operated for over a hundred years on the same general principle of steam generated in a boiler, expanded in a reciprocating engine and exhausted through a smoke stack to produce draft, some voice the criticism that the steam locomotive has failed to keep pace with the times and that its days are numbered.

What are the facts? For purposes of comparison, consider the typical 4-6-0 passenger locomotive or 2-8-0 freight locomotive exhibited at the Chicago World's Fair in 1893. With 19-in. cylinders, 165 to 180-lb. boiler pressure and using saturated steam, these locomotives of forty years ago developed less than 350 hp. per driving axle. This power output per driving axle was increased to 475 hp. in 1913; to 575 hp. in 1923; and to over 1,100 hp. in 1933. Similarly, the unit fuel consumption, expressed in lb. of coal per drawbar horsepower, was reduced to 6½ lb. in 1913; to 5 lb. in 1923; and to less than 3 lb. in 1933.

Contribution of Manufacturers to Development of Motive-Power

Hardly more than a cursory mention can be made of those features which have contributed so strikingly to the development of the modern locomotive. Improvements in boiler design have included the provision of larger proportionate grate areas and firebox volumes, water-circulating devices, and special alloy steels and irons which contribute to increased strength or corrosion resistance. Developed primarily by the initiative of the manufacturers, these materials have made it possible to attain pressures up to 300 lb. in the conventional fire-tube boiler construction, and a service life of side sheets and flues, for example, two or three times more than usual. Special grate designs and firebrick arches, also developed by the manufacturers and used in conjunction with modern front-end arrangements, have increased greatly the efficiency of combustion and over-all operating efficiency.

Somewhat over two decades ago the idea of the superheater was brought to this country from Europe and adapted by the railroads and the manufacturers to American needs, effecting a saving generally conceded to be about 22 per cent in unit fuel consumption. After a period of effective service, the superheater was further improved by the development of a new design which provided substantially less resistance to the free flow of steam through the units. Similarly, the development of the feedwater heater effected savings, conservatively estimated at 12 per cent in fuel and water, and provided proportionate increases in boiler capacity, drawbar pull at speeds, also reducing the number of stops for water and coal. These same objectives are achieved in a somewhat less degree, but at a lower cost of installation and maintenance, by the use of exhaust steam injectors. Thermic syphons, which provide an important safety feature in boiler operation, were developed primarily to improve the circulation of water in locomotive boilers and effect a fuel saving.

One of the principal improvements in the locomotive itself has been the provision of the locomotive bed frame, cast in a single piece, which takes the place of what were formerly 250 separate parts. Special sheets and irons and improved designs have been developed for pistons, rods, wheels, axles, trucks, valve gear and other important details. The locomotive booster and the auxiliary locomotive were developed to give increased tractive force at starting and on heavy grades. The mechanical stoker, power reverse gear, mechanical lubricator, cut-off or back pressure control, efficient air compressor, boiler operating safeguards and many other devices, developed largely through the initiative and research of the manufacturers, all contribute to satisfactory locomotive performance.

Electric and Internal-Combustion Equipment

Advances in electric locomotive design, equivalent to those effected in steam power, have been made possible in recent years largely through the engineering research and experiment work carried on by the great electric

* In computing traffic units, one passenger-mile is assumed to be equivalent to three ton-miles.

companies. These companies have also collaborated with the manufacturers of internal-combustion engines of the Diesel, distillate and gasoline types in developing power units which have, in many instances, demonstrated notable economies, particularly in switching service, where the high percentage of availability, low fuel consumption and low labor cost of operation, as well as reduced maintenance expense and freedom from standby losses, have effected savings estimated at $10,000, or more, per year per locomotive, depending upon the power developed. Operating costs in the meantime have frequently been cut about 50 per cent on an hourly basis, as compared with those of equivalent steam power.

Internal-combustion-driven rail cars, which are now largely of the electric transmission type, also have been developed and adapted to railroad needs through the co-operation of the manufacturers, who have produced highly efficient and reliable units. A midwestern railroad, which is a large user of this type of equipment, has shown, on the average, over a period of four years, 93.3 per cent availability; total operating costs, including interest and depreciation, 36 cents a mile; total saving over equivalent steam-train operation, 21 cents a mile; and total return on the investment, 123 per cent in four years.

Developments in Car Equipment

Important improvements in car equipment, both passenger and freight, have been made by the railroads in co-operation with the car builders, and with manufacturers of many materials and specialties far too numerous to mention in detail. The first passenger cars were lighted with candles and heated with wood-burning stoves, if at all, whereas the modern car is provided with an efficient steam-vapor heating system, in many cases having thermostatic temperature control, combined with means for cooling and conditioning the air in accordance with maximum comfort requirements. Modern electric lights and all the conveniences of an up-to-date club are provided. The first Pullman sleeping car was built in 1859, subsequent improvements including six-wheel trucks in 1876, the car vestibule in 1887, axle generators and storage batteries for electric light in 1899, and all-steel construction in 1907, the latter being a factor of far-reaching importance in promoting increased car safety, capacity and durability. Aluminum-alloy and light-weight alloy steel construction for cars are developments of the last two or three years.

As a result of research by the manufacturers in the development of these light-weight materials and also improved welding and fabricating methods, car construction appears to be entering a new era in which large weight savings over equivalent cars, as formerly built, will assist the railroads in meeting the modern demands for high speeds in both passenger and freight service and also contribute to operating and maintenance economies of substantial magnitude.

One of the parts of car equipment which has contributed greatly to safe and satisfactory operation and which has been particularly essential, because of modern high speeds, is the braking equipment. From the first, the air-brake manufacturers have devoted extensive test laboratories and engineering development facilities to the improvement of this vital part of railroad equipment. The most recent contribution of the brake manufacturers is the new freight-train brake which promises to afford important improvements over the present standard air brake in the application and release functions, and also to effect economies in maintenance. The large expenditures of the brake manufacturers in an effort to develop this and other improved brake equipment have supplemented an expenditure of over $2,250,000 made by the American Railway Association in recent power brake tests.

In connection with high speeds, it is interesting to note the efforts now being made to adapt streamlining to both locomotive and car construction in an attempt to reduce wind resistance and conserve power, or make this power available for higher operating speeds. The manufacturers have conducted wind tunnel tests, using small-scale models of equipment as now built and as proposed. Scientific effort of the highest order has been combined with practical ingenuity in developing and testing modifications of these streamlined car and locomotive models. Many changes in design have been suggested as a result of the tests and, in certain combinations, they are expected to decrease the air resistance 35 to 40 per cent at high speeds.

Another virgin field in which manufacturers are co-operating with the railroads is in the adaptation of rubber for car cushioning and noise prevention. This material is now being used at various points in the trucks, buffing devices and car structure; also in the wheels, sometimes in the form of rubber tires on special equipment, or in the wheel center plates to give resiliency and dampen noise and vibration. As most commonly used, the rubber is in compression, although the wheel center design mentioned uses it in shear, and a recent draft-gear design for light-weight equipment utilizes a serrated type of rubber construction which gives rapidly increasing resistance as the coupler is forced in or out.

The rubber manufacturers have a real opportunity to adapt their products to car conditions and, on the other hand, the railroads can no doubt modify certain features of car design so as to capitalize on the peculiar physical characteristics of rubber, and thus bring about a major improvement in the comfort and attractiveness of railway travel.

Roller bearings are no longer an experiment in railway service, having been used successfully in all departments and on practically all kinds of bearing applications. They have been tested to a limited extent on freight equipment and much more extensively on passenger cars, power rail cars, engine trucks, trailer trucks and tender trucks. Six steam locomotives on four roads have even the large main driving wheel journals equipped with roller bearings, which contribute in a striking manner to great reliability, reduced maintenance, economy in lubrication, easier starting and hauling, and increased mechanical efficiency. In general, these results are secured with roller-bearing equipment of all kinds. In addition, the conditions under which engine, trailer and tender-truck journals, for example, operate are often so severe as to make roller bearings practically the only type of bearing which will stand the abuse. In certain cases, the saving in truck lubrication, inspection and journal packing expense alone is said to go far towards paying interest charges on the investment in roller bearings. The average layman has little real appreciation of the exhaustive research in steel making, heat treatment, design and fabrication, the results of which the roller-bearing manufacturers have embodied in their respective products.

The lubrication of railway equipment has become a matter of extensive research, especially in recent years. The oil companies have experimented individually and conducted tests in conjunction with the railroads, to determine satisfactory grades of oil for various purposes, including a car oil which will meet all-year service requirements. Car-journal testing machines have been installed in laboratories where temperature conditions could be controlled and relative journal friction measured

under varying conditions and with different kinds of oils. Journal packing reclamation has also been the subject of the most careful investigation and test, in an effort to develop methods of treatment which would give more satisfactory packing and thus help to decrease the cost and increase the reliability of car-journal lubrication. Locomotive lubrication presents a vast field for research and engineering development in which the manufacturers of mechanical lubricators and various lubricating devices have made a substantial contribution.

Manufacturers' Associations Also Play Important Part

Railway car manufacturers, both individually and through their association known as the American Railway Car Institute, have contributed far more to car development in this country than is ordinarily appreciated. One of the most noteworthy accomplishments of this group has been the co-operation which it has accorded the American Railway Association, Mechanical Division, in the development of the standard car designs, adopted in the interests of economy, lower first cost of construction, and reduced maintenance expense. In the case of the steel-sheathed wood-lined box car, adopted as standard in 1932, the fundamental features of the design were laid down by the Committee on Car Construction of the Mechanical Division and the details developed by a committee of engineers representing the American Railway Car Institute. In this car, a weight saving of 3,000 to 4,000 lb. was effected without sacrifice of strength or carrying capacity. Indeed, certain weaknesses of previous designs were corrected. Individual car builders have promoted progress by developing all-welded hopper cars, welded cars with cast-steel underframes, improved refrigerator cars (including some mechanically cooled), small capacity refrigerators, tank cars and special equipment of all types.

In the important field of car trucks and parts, individual manufacturers have done most of the research and experimental work to date. For example, the cast-steel side frame was developed by the use of dynamic testing machines in the laboratories of two manufacturers. With integral journal boxes, this type of frame has effected a striking increase in safety, combined with an equally important reduction in truck maintenance expense. The one-piece cast-steel truck frame, where used, produces the same results, and is a product of notable research in steel making and foundry practice. A group of truck manufacturers, combined to form the Four-Wheel Truck Manufacturers' Association, is now developing a freight car truck design and special coil-elliptic spring suspension, which are intended to be generally acceptable, protect lading and equipment, prevent spring synchronism and permit higher speeds without sacrifice of safety. Other individual manufacturers have developed special truck designs and several spring snubbing devices designed to improve the riding qualities of car trucks.

In no detail of railway equipment has greater improvement been effected than in wheels, which have been the subject of co-operative research by the railroads and the manufacturers for many years. The Association of Manufacturers of Chilled Car Wheels maintains a central laboratory where continuous research in connection with this type of wheel has resulted in the present high standards of reliability, durability and generally efficient service. Similar improvements in wrought-steel wheels have been effected by a technical committee of the Association of American Steel Manufacturers which co-operates with the Wheel Committee of the American Railway Association, Mechanical Division, in connection with designs and specifications for this type of wheel. The laboratories of the individual steel wheel manufacturers are utilized in this research work. Exhaustive research and experiment have also been carried on by the manufacturers of cast-steel wheels in developing this type of wheel to its present high state of reliability and effectiveness.

The free interchange of freight cars and the expeditious handling of freight are absolutely dependent upon automatic couplers, the development of which has extended over a period of many years of co-operative action by the American Railway Association, Mechanical Division, and the Technical Committee of the Coupler Manufacturers. As a result of recent investigations of this committee, several proposals for revised contour and design have been advanced which promise to increase coupler strength approximately 5 per cent; contour wear limit, 40 per cent; and coupler gathering range, 15 per cent. The new design also provides a higher factor of safety.

Draft-gear manufacturers, through their individual engineering staffs and laboratory test facilities, have contributed greatly to the improvement of draft gears, developing materials and designs which will stand up under the friction loads and dissipate the large amounts of energy involved. The manufacturers are co-operating with the railroads in furnishing draft gears which meet the purchase specifications for approved draft gears for freight service, these specifications having been adopted as a result of extensive draft-gear tests conducted by the A. R. A., Mechanical Division, in its own laboratory at Purdue University, Lafayette, Ind.

Car roof and end designs, insulation media, hand brakes, door-operating mechanisms and other parts have been developed by the manufacturers, being perhaps more accurately classified in many instances as inventions rather than as resulting from research.

Shop and Enginehouse Developments

Endless research on the part of manufacturers of machinery and equipment used in railway shops and enginehouses has resulted in improvements from which the railways have benefited greatly. Back shops, repair operations and terminal conditioning work have been revolutionized within recent years. The introduction of heavy-duty machines and high-speed tool steel has effected notable economies in machining operations. The manufacturers who have promoted the development of gas welding and widened the scope of electric welding have performed a service in improving construction and repair operations and cutting costs of great value. The installation of spray-painting equipment and commercial lacquers, also direct products of research, has effected large savings in maintenance operation.

Locomotive boiler repairs have been greatly reduced by scientific research in water treatment. The cost of boiler inspection and maintenance is also greatly reduced by an inspection device which a manufacturer has developed for use in detecting broken flexible staybolts quickly and surely by means of an electrical contact which gives a positive indication of the condition of the tell-tale holes. This device is also an important safety feature and its use at regular monthly inspection periods is accepted practice under the Interstate Commerce Commission rules for the inspection of locomotive boilers. Still another comparatively new inspection process of great promise, developed by the manufacturers, is the X-ray examination of castings and welds which provides a method of detecting defects and flaws without testing these parts to destruction.

In addition to the usual machinery and equipment so essential to efficient enginehouse operation, a large

amount of engineering development and inventive genius has been embodied in coal-, cinder- and sand-handling facilities, boiler-washing equipment and facilities for steaming locomotives by direct connection from stationary boilers, thus eliminating locomotive fires and attendant smoke in enginehouses, conserving locomotive time at terminals, and saving fuel.

Track and Structures

But improvements in locomotives and cars were not enough, for without better tracks and stronger bridges, the heavy power could not have been used, and, without the successful application of the Bessemer, and later the open-hearth, process to the manufacture of rails and structural steel, the railroads would have been confronted with a well-nigh insurmountable obstacle in meeting this requirement. So also, the aid of the manufacturer in developing the use of manganese steel for frogs and crossings, in applying special high-strength steel in the making of bolts, angle bars and spring washers, in the exercise of inventive genius and designing skill in the development of rail anchors and in improving the design of rail joints and tie plates, was essential in the effecting of improvements in track comparable with the increases in the demands on it.

The railways owe much also to the manufacturers of portland cement for the progress made in the application of concrete in railway structures; and especially for improvement in the making of concrete that must be ascribed largely to research which they fostered. The manufacturers of iron culvert are likewise responsible for research in the nature of the loads carried by culverts buried in embankments and for improvements in drainage practices.

Research and invention carried on by the railway supply companies must be credited in even greater measure for power equipment which has effected a revolution in the methods employed in the upkeep of tracks and structures. The successful application of the gasoline engine to small track cars has supplemented the hand car in the moving of maintenance forces. Its development as a prime mover for power tools and equipment is rapidly eliminating hand labor in such operations as rail laying, ballasting, driving spikes, adzing of ties, turning of nuts on bolts, and the drilling and sawing of rails and timber. The electric arc and the oxyacetylene torch have been responsible for untold economy in the conservation of rail and in the repair and strengthening of bridges.

The availability of an adequate supply of water of good quality has been determined by improvements in power units, pumps, tanks and delivery equipment, and also by the improvements in the chemicals and equipment supplied by various manufacturers for water treatment; and the same observation applies to the facilities for the storage and delivery of coal, for the disposal of cinders and for the various classes of equipment employed in the servicing of locomotives in engine terminals.

Signaling

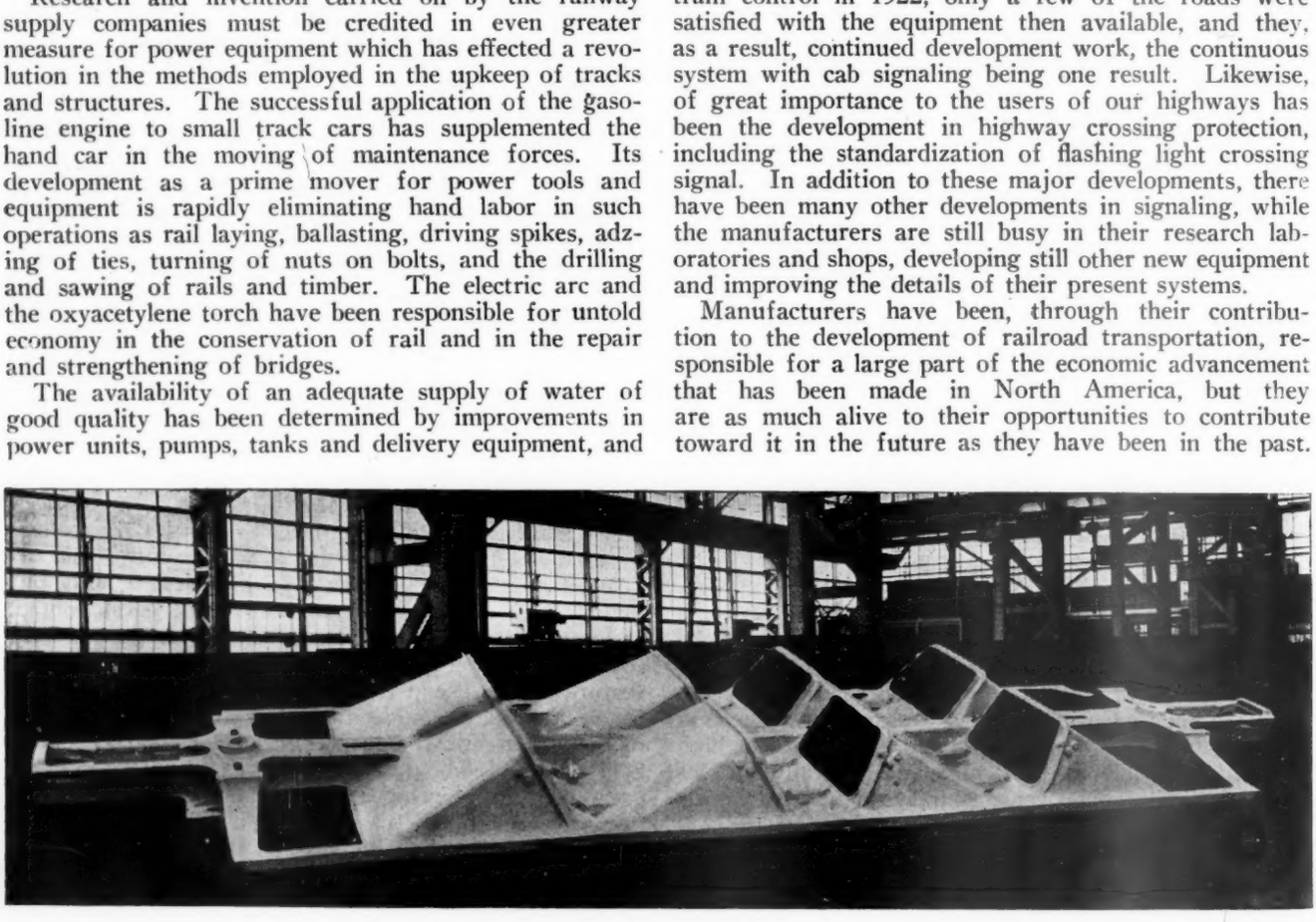
Along with the improvements in locomotives, cars and track, equally outstanding improvements have been made in signaling, which are not only greatly increasing the safety of train operation but also reducing train delays and increasing track capacity. Prior to 1920, signaling consisted of automatic block signaling, interlocking and highway crossing protection, while in the past decade, there have been added centralized traffic control, the car retarder and automatic train control with cab signaling.

Perhaps the most important of these is the centralized traffic control, by means of which a dispatcher can control the operation of passing track switches as well as the signals for directing train movements, thereby eliminating written train orders. By reducing delays, the average running time of freight trains is reduced more than a minute to the mile, while track capacity is, in many cases, increased to the extent that the construction of additional track can be postponed for years.

The invention of the car retarder has given the railroads a means of operating classification yards without car riders, thus facilitating yard operation and reducing operating expenses from 18 to 40 cents per car classified.

When the Interstate Commerce Commission ordered 49 railroads to make divisional installations of automatic train control in 1922, only a few of the roads were satisfied with the equipment then available, and they, as a result, continued development work, the continuous system with cab signaling being one result. Likewise, of great importance to the users of our highways has been the development in highway crossing protection, including the standardization of flashing light crossing signal. In addition to these major developments, there have been many other developments in signaling, while the manufacturers are still busy in their research laboratories and shops, developing still other new equipment and improving the details of their present systems.

Manufacturers have been, through their contribution to the development of railroad transportation, responsible for a large part of the economic advancement that has been made in North America, but they are as much alive to their opportunities to contribute toward it in the future as they have been in the past.



An Example of Modern Steel-Casting Art

Research Conducted by Railroads

Reviews what has been accomplished and recommends central control agency and special attention to merchandising research

By C. D. Young

Vice-President, Purchases, Stores and Insurance, Pennsylvania Railroad

IN this country railroad experimentation and research are coordinated to a considerable extent, though by no means entirely, through the American Railway Association. The major divisions of the Association embrace Operation and Transportation, Traffic, Engineering, Mechanical, Purchases and Stores, Claims, and Motor Transport. The credit for what has been achieved is largely due to the splendid cooperation of American universities and industrial research groups and certain governmental departments with the committees of the Association.

Better Track Service

The most outstanding work of the Engineering Division in recent years has been the improving of the metallurgy and physical characteristics of rail of heavy section. Practically unanimous agreement has been obtained on a standard section, and closest supervision is maintained by committee action over metallurgical composition of the rail, and rolling mill practices. Rail performance is being continually and minutely scrutinized and studied by all railroads in the desire to bring about improvements in rail and attachments, and the quality of steel of which they are composed. Illustrative of this, there has been developed an eminently successful rail fissure detector car, which is now in its fifth year of service, during which time it has located and led to the removal of more than 7,000 defective rails.

Other endeavors of the first rank have been directed to the solution of such problems as the battering of rail ends, and reducing abrasions. Continuous effort is being exerted in every direction and every detail, to the end of producing a safer track structure at the least expense. The preservative treatment of crossties, to prevent decay, has been a research activity of many years, not only by the railroads but by the United States Forestry Service. The advance which has been made in creosoting has, on the average, more than trebled the life of ties. Devising economical means of eliminating grade crossings has also been a major engineering problem.

Improved Passenger Equipment

In the field of the Mechanical Division, details are so voluminous that only some of the most outstanding can be mentioned. A very appropriate subject, at this season of the year, is the recent marked advance in air-conditioning of passenger cars. The art is in its infancy, and further improvement may be confidently expected. Essentially it manufactures and maintains artificial interior weather. Pre-cooling, which is especially adapted to sleeping-cars leaving after sunset, has advanced to the point where it is being successfully used at many of the larger terminals.

Much research and study is being focused upon the passenger car of the future. The railroads are seeking a design that will have increased public appeal by providing more comfort and seating convenience, better riding qualities, elimination of noise, and increased aesthetic appeal. An essential condition in designing new passenger equipment is that there shall not be the slightest sacrifice of the extremely high degree of safety which has been the preeminent advancement in passenger cars since wooden equipment was superseded by steel.

Roller bearings have been in use on passenger cars long enough to warrant the prediction that they are destined to supersede the journal bearing type. On other equipment this improvement is in the development stage, although it is being successfully applied to the journals of the heaviest locomotives—one eastern road has an entire fleet so equipped. While their first cost is much higher than that of bearings of the ordinary type, their durability and the freedom from train detention, due to bearing trouble, leave no doubt as to their value.

A most useful development, which has now been brought to a very advanced degree of perfection, is the multiple-unit car for electrified passenger service. Each car carries its own motor, thus making possible trains of any length and providing rapid acceleration, making practicable the high speed, frequent commutation service which a number of cities enjoy today.

There has recently been devised a striking innovation for suburban passenger service—a light weight car of double-deck type, providing a greatly increased seating capacity at about one-third the usual dead weight per passenger.

In addition, high-speed, light-weight trains, together with the possibilities of stream-lining, are receiving careful attention. The object is to develop equipment capable of providing service which will be fast, frequent and economical, thereby meeting the principal competitive advantages of the airplane, the private automobile and the bus. Interesting examples are trains which have been designed for two western railroads. They are to be completely stream-lined, and have a capacity of over 100 passengers, in addition to mail, baggage and a buffet kitchen. They will be capable of sustained high speed and be propelled by internal combustion engines.

Another interesting development is the pneumatic tired rail car, now in its first year of operation, constituting a self-propelled unit for suburban use. It reduces noise to the minimum and makes for greater comfort to the passenger.

Locomotive Development

The American steam locomotive has advanced so rapidly as to place many of the units that are now in daily operation in a position of obsolescence, replacement of which is awaiting the railroads' ability to finance. Experiment and research have developed it into a remarkable unit of concentrated power and economy. Since 1911 the average tractive power of the steam loco-

motive has been increased more than 60 percent. This has been one of the most important factors in advancing efficiency of operation, particularly in the case of freight, by making possible the concentration of traffic into long trains, moving unbroken over great distances. This has been an important aid in enabling the railroads partially to meet the ever increasing wage scale of train service employees.

To economize in the use of coal, superheaters, feedwater heaters and high steam pressures have been extensively adopted. For greater capacity, on long runs, and to reduce the physical exertion of the firemen, stokers have been generally, and generously applied. Over a period of about a dozen years, these means have been instrumental in reducing by 30 percent the coal consumed in freight service per gross ton-mile, which results in the annual conservation of twenty-five million tons of a great natural resource. The railroads are also saved the cost of handling this great amount of fuel, which is another, and by no means inconsiderable, item of economy.

Trend in Steam Locomotive Design

The trend in steam locomotive design is distinctly toward materially higher steam pressures and temperatures, which will consequently require material for the construction of boilers and their parts having still greater strength than that now generally in use. Great strides have been made, and will continue to be made, in simplifying locomotive construction by such methods as the greater use of single-piece steel castings, each taking the place of a considerable number of small parts. Increased capacity of locomotive tenders has resulted in expediting train movements by eliminating stops for coal and water, and simplification of construction details has lowered the cost of production.

Research has brought to light hitherto unrealized possibilities in the use of high-strength, light-weight materials for locomotive parts. As an example, studies and experiments are now under way to produce lighter reciprocating parts, which would naturally call for light counterbalances, with a corresponding reduction in the dynamic augment, so that higher locomotive speeds would be possible without damage to track structures.

The important extensions of electrification carried out in recent years are still under way and have led to the design of new and extremely useful types of electric locomotives. One of the most valuable features of these new units is that they are capable of being coupled together in any number, so that trains of any length and load may be hauled at almost any desired speed within the limits of safe operation. Another feature is that the parts are largely interchangeable as between freight and passenger locomotives, thus reducing to a minimum the supply of spare parts.

Freight Train Operation

Research in the field of air brakes has been one of the most important activities of the Mechanical Division of the American Railway Association. It has been continuously carried on since 1870. With the growing practice, in the interest of efficiency and good service, of transporting freight as far as practicable in longer trains at high speeds, there has developed the necessity for a more effective freight train brake. Under the auspices of the Mechanical Division, and with invaluable cooperation by universities and the industry, a brake has been produced which not only meets but surpasses the specifications of the Interstate Commerce Commission. It answers fully all requirements, providing full control at all times, regardless of the length of the train or diversity of its makeup. It is also completely interchangeable with the freight equipment brake now used.

The increasing use of long freight trains has also created operating problems which make desirable an adequate and satisfactory system of communication between the head and the rear of the train. This is a subject of active experimentation at the present time, with every indication of successful solution by adapting the radio telephone to this highly specialized purpose. Its introduction will further improve train speeds and safety, and reduce lading damages.

Another recent development is the use of non-harmonic springs on freight cars. These consist of a combination of helical and elliptical springs of different periods of oscillation, or of helical and friction springs. The effect is to dampen spring action and thereby protect the car contents from damage.

At one of our technical schools, the American Railway Association maintains a complete laboratory for continuous research in draft gears, couplers and their attachments. The results of these activities are also among essential factors permitting successful operation of long heavy trains.

Special Freight Equipment

Other activities of the Mechanical Division cover the use of portable containers in freight service. They are transported, usually five to eight at a time, upon especially equipped cars. They may be loaded by shippers, trucked to the rail terminal, and at destination delivered by truck to the consignee, without rehandling of their contents. They may also be used in station-to-station service in place of box cars, providing smaller and more flexible transportation units, thereby greatly reducing work and expense at freight transfers. Other advantages lie in simplified billing and packing, reduction of loss and damage, and accelerated movement of less-than-carload shipments. There is room for much additional research work to perfect this method of improved transportation through cooperative action between the railways themselves and with shippers and consignees and the trucking industry.

Development of special freight equipment, for miscellaneous commodities and special kinds of merchandise, has important possibilities which undoubtedly will be carried much further in the future. Already, covered hopper cars, equipped with loading hatches, are coming into use for such commodities as cement, lime, glass sand, phosphates and bauxite concentrates. These cars obviate bagging or barrelling, and give complete protection from the weather. Other commodities, such as helium gas, solid carbon dioxide, acids and other chemicals are economically transported by special rail equipment. Special cars for transporting automobiles are also appearing, having loading devices and cradles to eliminate decking and blocking, making it possible to carry more automobiles per car and to load and unload more cheaply. It will be observed that these special types of equipment reduce the cost of transportation to the shipper without impairing the revenue derived by the railroads.

Mention should also be made of the standardization of freight cars, of generally used types, which has been brought to a high plane in the aim toward simplification, facility of repair and sturdiness of construction.

Corrosive deterioration of freight cars, particularly of the open-top type, offers an opportunity to reap large rewards when a solution of the problem is available. Research has developed, though not yet on a commercial basis, alloys which will make this destructive factor a thing of the past. It is possible that quantity produc-

tion might lower the cost of these alloys to a point permitting their practical use.

In the Interests of Safety

Eloquent testimony in safety records of recent years show the unremitting efforts of various Divisions of the Association. In 1920, seventy-four passengers were killed in train accidents, and the average from 1922 to 1926 was 77 per year. The organized movement toward enforcing safety rules, and use of improved materials and construction in both road-bed and equipment, have reduced passenger fatalities almost to a vanishing point. In 1932 only one passenger on an American railroad lost his life in a train accident, although nearly 480,000,000 passengers were carried a total of 17,000,000,000 passenger miles.

Among important factors contributing to safety have been the improvements in the railroad signal systems. These include far-reaching extensions of the use of automatic block signals; adoption of the position light type of signals, in which the indications are given by rows of electric bulbs; and automatic cab signals, which reproduce, within the engine cab, the indications of wayside signals.

Research Laboratories

In its research work the Association, in addition to its own laboratory at Purdue University, utilizes laboratories of various member railroads, among which is the laboratory of the Pennsylvania Railroad at Altoona, which is supplemented by locomotive and brake shoe testing plants; the New York Central laboratory at West Albany, N. Y.; and laboratories of the Santa Fe, Union Pacific and other important lines. These splendid testing plants are well adapted to physical research, but of course do not generally touch the great possibilities of research into problems involving competitive business practices. The Railway Executives in the summer of 1932 issued a public statement to the effect that they were utilizing, and proposed in the future to utilize even more effectively, their organizations for research and experimentation and to take all other available measures to secure the utmost in operating efficiency. They took the further position that the public was entitled to have the most efficient system of transportation possible to create, including all available agencies; and that the public had the right to use each agency in the manner and to the extent justified by its effectiveness and economic cost, but only upon terms just and equitable to all. That these principles have been, and are, actually in effect is demonstrated by the accomplishments of which I have spoken, and which are manifestly of utmost value to the cause of transportation progress.

Recommends Central Research Bureau

In the Interstate Commerce Commission's report on consolidation of railroads the concurring opinion of Commissioner Joseph B. Eastman, now Federal Co-ordinator of Transportation, contained the very pertinent declaration:

> "The desirability of cooperation by the railroads through some central agency, like the American Railway Association, in all matters where their special interests are not in conflict. Considerable has been done along these lines, but much more is possible. It should include provision for a highly organized central research department. . . . In my judgment, many of the advantages which are urged in support of railroad consolidations on a grand scale can be realized in a better way by such a policy of intelligent cooperation."

I agree with this view. I believe that under the jurisdiction of the Executives of the American Railway Association there should be appointed a Director of Research. His duties should be to co-ordinate all research activities of all divisions and bureaus, plan the work to be done, allocate direct where it should be conducted, decide sequences of activity, and in general to pursue many inquiries which at present are difficult owing to the competitive conditions between railroads themselves and other modes of transportation.

Railroad research work, as now conducted, divides itself into two general classes: first, that which is centrally directed, such as improvements in air brakes and draft gears, standardizing box cars, the work of the Bureau for the Safe Transportation of Explosives, development and use of freight containers, their loading and stowing; second, the work which is constantly progressing in laboratories of the individual railroads and institutions; and the experience gained through actual operations upon railways in conjunction with these experimentations. Some of the results of the second classification are promulgated through the central organization, acting as a clearing house for dissemination of the information to the railroads.

Research in Merchandizing Railroad Service

Speaking for myself alone, there should be a third class of centralized research work, involving what might be termed the business affairs of the railroads. This group of problems should be taken up much more aggressively than has been the case in the past. Under this third classification would fall such matters as studies involving a sounder basis for making and adjusting rates and fares; new forms of transportation service and improvement of existing facilities; coordination of rail transportation with other agencies of service; better salesmanship as an aid to more effective solicitation of business and other kindred subjects. Research into such matters, carried on under central direction would be free from competitive self-interest and would permit unimpeded study for the benefit of all.

Need of Central Control Agency

Let us see our problem straight. I believe it will be admitted that, born in competition under the requirements of law, many of the uneconomic practices in the transportation field today are due to the lack of one central control agency whose interest would be exerted for the benefit of all. This has resulted in efforts on the part of individual carriers to seek opportunist solutions, perhaps momentarily benefiting themselves but often disastrous to their neighbor, and in so doing, uneconomic practices have been supported which have their origin in competition from within and without.

Under such central direction, controlled by a governing body, wholly within the railroads, it is not difficult to visualize closer cooperation between the railroads themselves, and if the industries which they serve could be similarly organized as concerns transportation matters, such coordination would tend to stabilize market conditions and so prevent unwarranted and ruinous price cutting in times of declining business, as well as to insure an adequate supply at reasonable cost in times of commercial activity. At all times industry, and likewise railroads, need price stabilization within reasonable bounds.

There should be more intelligent and intensive advertising of railroad service, a clearer analysis of the needs and desires of the traveling and shipping public and a more thoughtful study of problems of coordinating and unifying the various agencies of transportation. Centralized research would not neglect the foregoing possibilities.

Universities Are Important Contributors to Railway Research

Extensive laboratories at Purdue and Illinois have long been devoted to investigation of technical problems of the railroads

AN impressive picture of the wide range of technical railway problems which have been the subjects of investigation and research in the laboratories of universities is presented in two papers which were read at the Railroad Division sessions of the American Society of Mechanical Engineers.

In his Review of Forty Years of Railway Engineering Research at Purdue University, Gilbert A. Young, head of the School of Mechanical Engineering and director of the mechanical engineering laboratories, dealt briefly with 54 investigations which, with other minor studies, include over 110,000 tests at a total cost in the forty years of approximately $4,285,000.

These investigations relate to locomotive boiler and engine efficiencies, to the operating features of car equipment, studies of the stresses in railway equipment under static loading, and include those conducted on the American Railway Association testing machines which are deposited at Purdue.

In a similar review of railway research at the University of Illinois, Edward C. Schmidt, head of the Department of Railway Engineering, and Everett G. Young, research professor of railway mechanical engineering, review 18 major projects, most of them devoted exclusively to railway investigations and others of a general character, in the benefits of which the railways have shared. The investigations of railway problems are of two classes: Those carried out in co-operation with the railways and other organizations and those initiated and carried out by the Department of Railway Engineering itself.

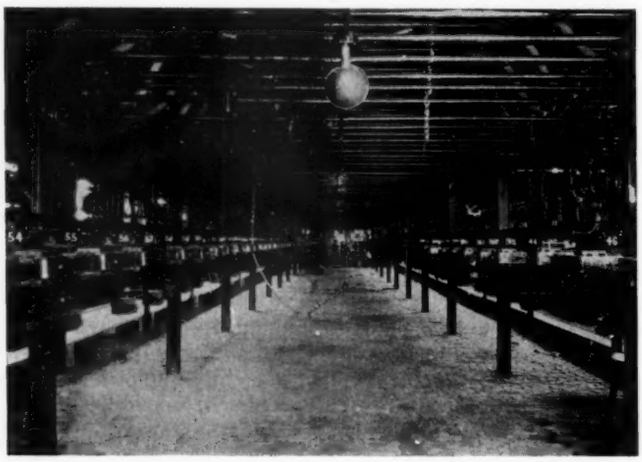
In addition to these two universities which have long specialized in the engineering problems of the railways, specific projects have been carried out at many other universities from time to time which, in the aggregate, have made a measurable contribution to the technical progress of railway transportation.

Space permits of presenting a brief abstract only of certain projects described by the authors of the two papers, which have been selected for their value in showing the character of the part played by the universities in the technical progress of the railways and the extent of the equipment and personnel that have contributed to the conduct of this work.

Forty Years of Railway Research at Purdue

By Gilbert A. Young
Head of the School of Mechanical Engineering and Director of Mechanical Engineering Laboratories, Purdue University

It is the fortune of few men to impress themselves on an institution and on a generation as did the late W. F. M. Goss, the first Dean of Engineering of Purdue University. The work and life of Dr. Goss contributed greatly not only to the railways of the world, but also to the shaping of the careers of hundreds of engineers who were students at Purdue University and at the University of Illinois during his connection with these institutions.



American Railway Association Power-Brake Laboratory at Purdue University

Throughout the twenty-eight years of his service at Purdue the railway was the outstanding development of America. Early he saw the necessity of the scientific method in the study of its motive-power problems, and to his unflagging zeal in its application, the nation in general, and Purdue in particular, owes a lasting debt of gratitude. Supported by the president, Dr. James H. Smart, Professor Goss secured for Purdue the first locomotive testing plant in the world—his own design. From that day the locomotive had to render an account of its service.

Following the scientific conquest of the locomotive, Dr. Goss led the way in the systematic testing of other parts of the running train; successively, the air brake, the brake shoe, the car coupler, the draft gear, and even the wheels themselves have received critical examination —under his direction or through the continuing presence of his inspiration.

The Use of Superheated Steam

The history of the introduction of the use of superheated steam is interesting due to a number of years elapsing after its first use a hundred years ago in 1832 to the time, fifty years later, when it was generally recognized as a means of increasing engine economies. After the early reciprocating engine had passed through the

experimental stage, superheating had been employed and proved its value, but it was gradually abandoned by the majority of engineers and not again resorted to until successive stages of increasing pressures, ordinary compounding, jacketing and refined designing had been brought to their greatest perfection.

With the introduction of hydro-carbon lubricating oils, balanced valves and improved packing, the use of considerably higher temperatures became possible and, in 1890, interest in this subject was renewed by the attention drawn to the results which were being accomplished in Germany.

One of the first researches undertaken in the Purdue University locomotive laboratory on Schenectady No. 1 * in 1893 was to determine the amount of superheat given to the steam by passing it through the smokebox on the way from the dry pipe header to the cylinder. The results indicated the possible value by utilizing the waste heat in the smokebox by the so-called smokebox superheaters which had been introduced into locomotive design by European builders.

Under the auspices and patronage of the Carnegie Institute of Washington and in co-operation with Purdue University an extensive series of locomotive tests was started in 1904 and finished in 1905. The first series of 100 tests had for its purpose the determination of the performance of a locomotive using saturated steam, and, the second, that of a locomotive using superheated steam.

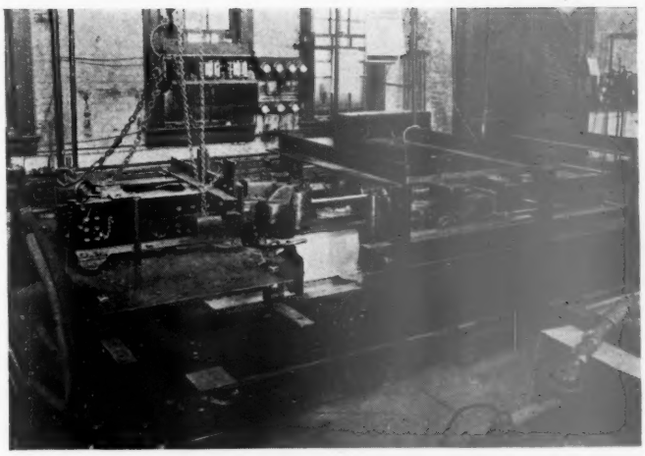
In the superheated series, reported to the American Railway Master Mechanics' Association in 1909, the results showed that the higher evaporation efficiency was obtained with the lowest boiler pressure and that the degrees of superheat increased as the boiler pressure decreased, varying from 134 deg. F. at 240 lb. pressure to 170 deg. F. at 120 lb. pressure. The average pounds of coal per indicated horsepower in the superheated series was 3.09 and for the saturated series was 3.57, showing a 10.9 per cent increase in favor of the superheated locomotive.

The previously reported tests seemed to show a progressive improvement in the efficiency of the locomotive with an increase of superheat. Because this apparent improvement in the efficiency had not reached a maximum, it was decided to increase the temperature of superheat. While the maximum degree of superheat in these experiments was only 240 deg., two very important conclusions resulted; namely, "A locomotive equipped with a superheater giving 200 to 240 deg. of superheat will, during the time of running, effect a saving in coal consumption of from 20 to 30 per cent over that of the same locomotive using saturated steam. It would seem that the total gain in efficiency which could be obtained from superheat in a locomotive would not be reached until the temperatures became too high for practical purposes."

As the superheated locomotive used 15 to 20 per cent less fuel at the same power, a study was undertaken in 1912 to determine the increase in power of the locomotive when using the same amount of coal that would be used if operated on saturated steam.

The results showed that the power of the superheated locomotive varied with the steam pressure and in the range of these experiments increased from 22 per cent [200 lb. per sq. in.] to 13 per cent [120 lb. per sq. in.] when burning the same amount of coal as was used when used as a saturated engine. The results also revealed the fact that if the maximum efficiency were maintained,

* Professor Young included in his paper a brief description of four locomotives which have successively belonged to the Purdue University test plant. These were Schenectady No. 1, 1891 to 1897; Schenectady No. 2, 1897 to 1902; Schenectady No. 3, 1903 to 1923, and Vauclain-Purdue No. 4, 1924 to date.



A. R. A. Testing Equipment for Automatic Train-Line Connectors

this increase in the available power with the same water heating and superheating surfaces would allow an increase in cylinder size, which is now 16 in. in diameter, to 18.75 in. This would mean an average increase in indicated horsepower of nearly 29 per cent.

The value of superheating is now an old story. Please remember it was not an old story in 1905. It was pioneering work and Dean Goss had to have the adventurous spirit of a pioneer to equip the test locomotive with four types of superheaters and demonstrate to doubting unbelievers the value of superheated steam in locomotive service.

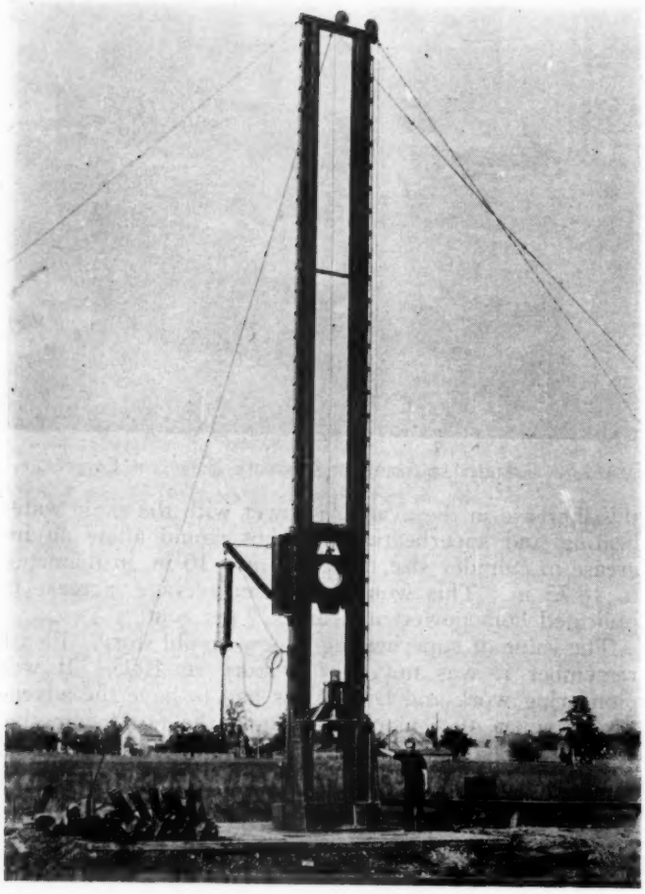
Early Development of the Front End

The American Railway Master Mechanics' Association became interested in the proper design of exhaust nozzles as early as 1890 and some years later appointed a committee to co-operate with Purdue University in the solution of this problem. The investigation took the form of a study of the form and action of the jet of exhaust steam in the front end of a locomotive and was undertaken at the Purdue Locomotive Laboratory in 1895 on Schenectady No. 1. From the results of this study a recommended size, shape and height of exhaust nozzle was determined. The limiting facts thus obtained were adopted by the American Railway Master Mechanics' Committee for recommended practice in 1896.

This study was accepted so favorably by the railroad officers in settling the question of proper design of the exhaust pipe and nozzle that the American Engineer and Railroad Journal, under the able leadership of its editor, G. M. Basford, in 1902 offered to sponsor an investigation of locomotive smoke stacks at Purdue University. A committee of 12 motive power officers from the railroads were chosen as advisors. The question to be solved by this investigation was the form, diameter and height of the stack and effect on the power of the locomotive. It was assumed that the previous work on exhaust nozzles would be a start to the whole problem.

When the report was published in the American Engineer and Railroad Journal in 1903 the results were so outstanding and in many ways so radically different from preconceived ideas that it was felt that further investigation was desirable, chiefly because the Purdue locomotive was smaller than those used throughout the United States.

The members attending the annual convention of the American Railway Master Mechanics' Association in 1903 expressed a common desire to have the experiments repeated upon a locomotive of large size and to have the study extended to include the draft-pipe problem,



The First A. R. A. Drop-Testing Machine—The Tup Weighs 1,440 lb.—A 27,000-lb. Machine Is Now in Use

the effect of inside stacks and of false tops in the smoke arch. It was not until November, 1905, that all the plans were matured and the New York Central Atlantic type locomotive was delivered to Purdue University and the tests continued six days a week until the following April.

There were many co-operating agencies who aided in this new series, among which was the continued assistance of the American Engineer and Railroad Journal, which initiated and sponsored the original study in 1902; the Standard Oil Company, which presented a carload of [fuel] oil; contributions from 74 railroads and two locomotive building companies, besides the generous part which the officers of the New York Central took in making the whole investigation possible.

The conclusions drawn from the results secured in this elaborated series of experiments were conclusive and far-reaching as to their influence on front-end design. Out of the combined series of experiments came the standard front-end known the world over as the Master Mechanics' front end, which was adopted and is still, nearly 40 years later, generally used in locomotives of today.

A. R. A. Testing Machines At Purdue University

The testing machines for the standardization of railway equipment, formerly owned by the Master Car Builders' Association, and now under the direction of the Mechanical Division, American Railway Association, which have been deposited at Purdue University include the air-hose testing apparatus, a drop testing machine for impact, a brake-shoe testing machine, and an air-brake testing rack.

The two new machines built for special lines of investigation under the co-operation and direction of Purdue University and the American Railway Association are the draft-gear testing machine located in a new laboratory building, the cost of which was borne by the American Railway Association, and two automatic-train-line-connector test machines.

The last pieces of equipment to be deposited at Purdue are the tank-car outlet valve impact testing equipment and the tank-car safety-valve machine. These are jointly owned by the American Railway Association, the American Petroleum Institute and the American Railway Car Institute.

While the first of these testing equipment came to Purdue University in the late nineties, the last three were either deposited or constructed at Purdue during the last five years. Most of these machines are used for laboratory instruction of the mechanical engineering students, for research by the different committees of the American Railway Association, and for experimental purposes by those seniors and graduate students who are specializing in railway engineering.

The Air-Brake Laboratory

The story of the testing rack for the experimental study and the standardizing of air-brake valves is one of interest, because its development is indicative of the growing importance of this phase of safety in railroad operation. The air-brake testing rack was first located in Altoona, Pa., but was brought to Purdue University in 1899.

The equipment in the air-brake laboratory was completely over-hauled for the fourth time and rearranged and the laboratory was renamed in 1925 preparatory to an investigation of power brakes by the American Railway Association. The brake-pipe line from hose connection to hose connection was increased from 42 to 50 ft.*, the rack was lengthened to accommodate the latest air-brake equipment, and two new locomotive brake equipments were installed on the locomotive test rack. Specially designed trainagraphs were installed, together with many automatic devices designed to eliminate the personal equation from the readings taken to secure comparative data.

Actual tests were started on the A.R.A. investigation November 30, 1925, and completed January 24, 1929, and in this period 2,697 complete tests were made on the test rack under the general direction of the director of research of the American Railway Association and the immediate supervision of his assistant and the head of railroad work at Purdue University. Twenty-two men were employed in operating the rack and securing the data. One or two representatives of the Interstate Commerce Commission were present at all times when the tests were performed during the whole period of six years.

During the period when tests were being made on the rack another force of 66 men was tabulating and analyzing the results of these tests. At the completion of the rack tests a report was prepared in which the director of research of the American Railway Association recommended that the standard K equipment, and the Westinghouse type FC-5 and type FC-3 equipments be submitted to road tests under actual service conditions.

The director of research's assistant, the head of the railroad work at Purdue and 20 investigators were taken from Purdue University to the Pacific coast to conduct these tests. The tests were started August 1, 1929, and

*When first installed the dimension from hose coupling to hose coupling was 38 ft.

were completed March 31, 1931. During the progress of these road tests another force of 40 men located at Purdue University were busy compiling the data from the records of the tests.

The six years of investigation of power brakes created a nation-wide interest among the railroad officers as over 5,000 visitors came to Purdue University to witness the tests.

Research at the University of Illinois

By Edward C. Schmidt,
Professor of Railway Engineering and Head of the Department of Railway Engineering, University of Illinois
and
Everett C. Young,
Research Professor of Railway Mechanical Engineering, University of Illinois

The establishment of the Engineering Experiment Station at the University of Illinois was due chiefly to the efforts of L. P. Breckenridge, professor of mechanical engineering, who became its first director and continued in that office until he left the University of Illinois in 1909 to become the head of the Department of Mechanical Engineering at Yale University. Since that time the directorship has been vested in the dean of the College of Engineering, and the present director is Dean M. S. Ketchum, who has presided over the operations of the Station since 1922. In the thirty years of its existence the Experiment Station has completed investigations in nearly every field of engineering and in physics and chemistry, the results of which have been published in 255 bulletins and 21 circulars.

For distinctively railway investigations the equipment of its Department of Railway Engineering is unexcelled. This comprises a dynamometer car (owned jointly with the Illinois Central), an electric test car, special railway electrical laboratory equipment, a brake-shoe testing machine, a drop-test machine, and a locomotive testing plant fully equipped to test any existing steam locomotive, except a few of the largest articulated types. In its scope and availability this equipment is equalled only by the facilities of the Altoona laboratories of the Pennsylvania Railroad.

Studies of the Stresses in Railway Car Wheels

In the fifty years preceding 1920 freight-car wheel loads had increased fourfold. That wheel design, although in the main dependent upon empirical processes, had kept pace with the demands, is clear from the fact that the weight of the wheel, within this interval, had increased by only 60 per cent and that it continued to be adequate. About twenty years ago, however, the wheel manufacturers' difficulties were becoming acute; wheel load was still increasing, braking service was becoming more severe, and flange dimensions were sharply limited by the design of frogs and other track special work. The situation called for much more information about the stresses in wheels than was then available.

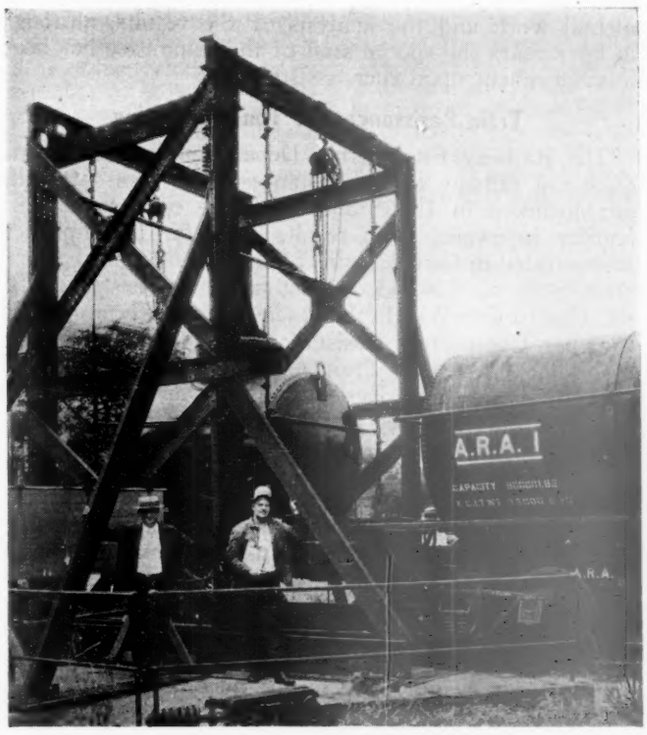
In these circumstances the University, upon request of the Association of Manufacturers of Chilled Car Wheels, agreed to co-operate with them in an extensive study of the stresses set up in wheels under the conditions of mounting and use. This investigation was made by the Department of Railway Engineering, acting in behalf of the Engineering Experiment Station. The program as finally carried out included tests to determine (1) the strains caused by mounting the wheel on its axle; (2) the strains caused by the static wheel loads; (3) the strains caused by flange pressure and the ultimate strength of flanges, and (4) the strains due to temperature gradients in the wheel arising from application of the brakes.

On the basis of the results of these tests the Association of Manufacturers of Chilled Car Wheels revised and completed the redesign of chilled iron wheels, which it already had under way. Concerning their usefulness, F. K. Vial, vice-president of the Association and of the Griffin Wheel Company, than whom no one is better qualified to speak, has said:

"The far-reaching effect of the co-operation in research of an industry with a university is particularly well exemplified by this investigation, which has resulted in the entire redesign of the chilled tread wheel into a much simpler and far more reliable form. * * * When you consider that the manufacturers of the chilled tread wheel are responsible for 24,000,000 wheels in service, requiring 3,000,000 per year for renewals, and were nevertheless willing to turn their back on the old design which had successfully carried the rail-borne commerce of the United States for a century, you may be assured that we knew we had reliable technical information upon which to base this radical departure."

Tests of the Thermic Syphon

Early in 1930 the Experiment Station entered into an agreement with the Illinois Central and the Locomo-



Tank-car Outlet- and Safety-Valve Testing Equipment Jointly Owned by the American Railway Association, the American Petroleum Institute and the American Railway Car Institute

tive Firebox Company of Chicago to test the Nicholson thermic syphon, which is manufactured by the Locomotive Firebox Company and is used extensively on this railroad. The tests were made by the Department of Railway Engineering in its locomotive laboratory. They were begun in April, 1930, and completed during the summer.

The syphon has been available since 1918 and at the time of these tests about 13,000 were installed on the locomotives of American and Canadian railways. Although it had previously been subjected to numerous road tests, the results given in Bulletin 220 constituted the first published record of tests of this device made in a locomotive testing plant where the test conditions can be fully controlled. The gain in efficiency due to the syphons ranged from 11.6 per cent at the lowest rate of evaporation to 6.6 per cent at the highest rate.

Stresses in Railroad Track

This item in the group of co-operative researches refers to the work carried on by the joint Committee on Stresses in Railroad Track of the American Railway Engineering Association, the American Railway Association and the American Society of Civil Engineers. The committee has been in existence since 1914 and its work still continues. From the outset its chairman has been Dr. A. N. Talbot, for many years head of the Department of Theoretical and Applied Mechanics of the University of Illinois and, since 1926, professor emeritus.

The University's relation to this research has been different from that it has borne to the other co-operative investigations. Its relation to it has been informal and has been maintained chiefly through Professor Talbot. All the office work of the committee has gone on at the University, and its special research staff has been housed at the University since the beginning. Such experimental work, other than railway field work, as has been involved has been done in the University's laboratories and, especially in the early stages of the work, members of its staff have contributed in important ways to the experimental work and the analysis of the results, although in later years the special staff of the committee has been less dependent upon such assistance.

Train Resistance and Tonnage Rating

The Railway Engineering Department's investigation of steam railway train resistance began soon after its establishment in 1906* and has since continued at irregular intervals. The results thus far accomplished are recorded in four bulletins of the Engineering Experiment Station: No. 43, "Freight Train Resistance; Its Relation to Car Weight;" No. 59, "The Effects of Cold Weather Upon Train Resistance and Tonnage Rating;" No. 110, "Passenger Train Resistance," and No. 167, "Freight Train Curve Resistance on a One-Degree Curve and on a Three-Degree Curve."

The freight-train resistance tests were made on a considerable number of ordinary freight trains in regular service on the Illinois Central Railroad. Their purpose was first to establish reliable values of net train resistance for operation on good main-line track, and in the second place to try to define the influence of car weight upon net resistance. There was at the time no very reliable experimental data available with respect to either subject. The general conditions of track, car construction and car weight have in the meantime changed so little that the results of the investigation are still applicable.

*This investigation was initiated by the Department of Railway Engineering of the University of Illinois and was carried out through the co-operation of the Illinois Central.

The test results embodied in Bulletin 59 (The Effects of Cold Weather on Train Resistance) are a by-product of the resistance tests in moderate weather, which have just been discussed. Whenever during these tests the air temperature turned out to be much below 40 deg., the derived resistance values were greater than usual. As such tests continued to be encountered, it became obvious that these apparently abnormal values were merely due to the effects of the low temperature. This bulletin is consequently neither comprehensive nor definitive, but it presented for the first time direct and quantitative experimental evidence of the increase in train resistance with decrease in temperature, and it has proved to be suggestive and useful.

The passenger-train resistance investigation (Bulletin 110) in its purpose and scope was similar to the freight resistance study. The work comprises the results of tests with 28 trains. The results of this investigation have been widely accepted as a valid contribution to the general subject of train resistance.

The curve-resistance tests recorded in Bulletin 167 constitute one of the very few direct experimental determinations of curve resistance made on American railways. The resistance due to curvature was found to be about 0.5 lb. per ton per degree of curve.

A Study of the Locomotive Front End

The correct design of the portion of the locomotive known as the front end, including the exhaust pipe and nozzle, the smoke stack, and such other devices (damper, baffle plates, diaphragm walls, netting, etc.) as are utilized in the effort to obtain the most satisfactory draft action, is a major problem. Front-end action is peculiarly well adapted to laboratory investigation, and the most important contributions to the knowledge of the subject have been made either by laboratory tests of locomotives, or by tests of front-end models. The Department of Railway Engineering chose the latter method as a means of studying the laws governing front-end action and has carried on an investigation over several years, the results of which are about to be published under the title "A Study of the Locomotive Front End, Including Tests of a Front-End Model."

A series of tests in which a number of nozzles identical in all dimensions, except diameter at the mouth, with a single stack, and a fixed resistance to air flow through the model, gave a basic generalization of results. Each successively larger nozzle of the series showed a smaller exhaust pressure for a given rate of steam flow, accompanied by a smaller corresponding air flow. Selecting one of the nozzles of this series, with this stack and air resistance as a standard for comparison, improvement in performance requires a lower exhaust pressure or a larger air flow (or both) for a given steam flow. If the nozzle of medium diameter is chosen as a standard of comparison, it is found possible to make such an improvement in performance by the following methods:

(a) Improvement in the form of the nozzle.

(b) Improvement in the diameter and taper of the stack.

(c) Increasing the height of the stack and the distance between the top of the nozzle and the top of the stack.

(d) All of the foregoing being based on a constant resistance to air flow, the reduction of this resistance made a significant improvement.

The investigation as a whole confirmed the value of standing front-end tests of locomotives, with certain improvements in method obviously desirable. The data from this investigation with a model reflect every recognized principle governing the front-end action so accurately that the additional information derived can be applied to the locomotive with confidence.

Research in Many Fields Contributes to Equipment Development

Discussions by railway men and manufacturers show a wide range of agencies which have co-operated in the technical advancement of locomotive and car design

FOLLOWING the formal reviews of the contributions of research conducted by the railroads, by the industries and by the universities, which were presented at the morning Railroad Division session at the spring meeting of the American Society of Mechanical Engineers, an afternoon session was given over to the discussion of the relation of research in the development of many specific features of motive power and rolling stock. Roy V. Wright, managing editor of the *Railway Age,* presided at this session and fifteen railroad men and manufacturers presented 10-min. discussions. Brief abstracts of these discussions follow.

A. R. A. Standardization of Freight Equipment

By F. H. Hardin
Assistant to President, New York Central Lines

The American Railway Association has long realized and recognized the many advantages which would accrue through standardization of the principal types of freight equipment cars used on American railroads, and over a period of a number of years, efforts have been made from time to time to attain this objective in the form of a practical reality, but for various reasons, success has not in the past crowned these efforts. To the average shipper or user of freight cars, this situation might appear incomprehensible, but upon close scrutiny, the magnitude of such an undertaking, the many difficulties to be overcome and the conflicting interests to be satisfied, immediately become apparent.

The work of the association as now constituted is of a strictly co-operative nature, persuasion rather than vested authority being the principal lever of accomplishment available to the responsible committees.

The advantages of such standardization, however, are many. A few are reduced cost of production and maintenance to the railroads, with ultimate corresponding reduction in freight transportation costs; reduced production delays; more systematic progress in design improvement and the smoother handling of freight offered for movement through elimination of complications resulting from numerous sizes and capacities of cars.

Although in the aggregate a considerable number of single sheathed box and all-steel hopper cars have been built to the drawings of previously prepared standard designs with certain modifications, the situation was such during their creation that certain restrictions were imposed upon the designing committees and the designs are not quite up to the standard that can be produced today.

The problem in its present form then becomes one of producing designs representing the latest state of the art with reference to weight, cost, construction, strength and general utility so that, when completed, they would be too attractive for railroads to disregard and would be of such character that any road might properly and consistently adopt them as standards and construct its future cars thereto even though not required to do so.

Immediately after the June convention in 1931 a program was formulated and, in view of its underlying importance, this program, consisting of six items, is here given in full:

1—Disregard existing A. R. A. fundamentals, design standards and recommended practices pertaining to car body construction and details where, if followed, the efficiency and value of the design as a whole would be adversely affected.

2—Request the full co-operation and assistance of the builders in the design work through the Committee on Car Design of the American Railway Car Institute.

3—Review the design each year and make revisions as may be considered necessary or desirable so as to keep it currently up to date and representative of the latest state of the art.

4—Design the car body so as to provide satisfactory applications of the principal proprietary specialties for a car of this type, i.e., doors, ends and roofs. At the same time, make proper provisions for designs of these items to be prepared by the builders. In the event development of satisfactory applications for both constructions to the same basic car structure is found to be impracticable, then changes in the structure necessary to accommodate either one group or the other are to be made in order to accomplish this result.

5—All A. R. A. member roads are to be licensed by the car builders to use without royalty any of the constructions or details incorporated in the design by the builders, on which they now may hold patents, have patents pending or for which later they may file applications.

6—Take advantage of available information relating to maintenance and service of existing cars of this general type.

In August, 1931, the chairman of the committee called the first joint session with a Design Committee appointed by and representing the American Railway Car Institute. The work was pushed so vigorously by all concerned that during the June convention of 1932 complete drawings and specifications were presented to the association for vote and adoption under its regular letter-ballot procedure as a standard design for generally unrestricted interchange service and the car was promptly adopted as such.

For quantity production and general interchange service, it was necessary to keep this design free from experimental features or expensive alloy materials and construction methods unestablished in railroad service. Regardless of this limitation, some 3,500 lb. of weight were saved in the superstructure alone. The trucks and certain other large castings offer further definite pos-

sibilities of weight reduction through co-operative research as soon as the work can be pursued to a conclusion. Still more progress along this line may be made in the form of welded construction and possibly through the use of alloy materials, as soon as the state of the art permits.

Five sample cars are now on order and under construction for the American Railway Association.

Before concluding, it is desired again to direct special attention to Item 3 of the program which definitely should dispose of one of the principal objections to previous association work of this character.

At present, the joint Design Committee is actively engaged in producing new designs of 50- and 70-ton nominal capacity hopper cars as the next step in this progressive movement, and it is hoped that the essential moral support to insure success may be forthcoming from all concerned, including the shippers and the railroads, to the definite advantage of all directly or indirectly affected and benefited by American railroad prosperity.

Car Trucks and Steel Castings

By Harry M. Pflager,
Senior Vice-President, General Steel Castings Corporation

Steel castings were used to some extent in England and on the European continent, as well as in America, prior to 40 years ago, but it was about that time that they began to be made in quantities. All of the earlier steel castings were made in the same manner as iron castings and similar designs were utilized. It was, however, quickly recognized that in order to use cast steel to the best advantage primary consideration would have to be given to the design of castings by engineers in order to obtain the full advantage and expected results from cast steel.

A new branch of engineering has been evolved with the increase in the use of steel castings. The art of making steel castings has been completely revolutionized, as the engineer, chemist, physicist and metallurgist have become increasingly important factors in steel foundry work. But the increasing attention that has been given to the design of the cast-steel structure has been in large measure responsible for the degree of perfection which has been reached.

Development of Cast-Steel Trucks

In 1900 the first cast-steel truck side frame was made for use with separate journal boxes and the following year the boxes were cast integral with the frame. The use of the integral-box frame has progressively increased and many improvements have been made in its design and manufacture. As a result of the extensive engineering study and research conducted by the manufacturers, freight-car truck maintenance, formerly the major item of expense, has with the cast-steel truck become almost negligible.

In 1905 the first one-piece cast-steel truck frame was made for a passenger car. This was of the four-wheel type and embodied in a unit not only the side and cross members, the brake and swing hanger brackets and equalizer spring caps, but also the pedestals were cast integral with the frame. While the integral pedestal has become almost the universal practice today, it was not generally used after this initial application until about 1917. It was thought that an integral pedestal broken in an accident would be difficult to repair and not until recent years was this objection overcome.

The First Six-Wheel Cast-Steel Truck

The initial application of cast-steel six-wheel trucks to a passenger car was made by the Pullman Company on one of its sleepers in 1905. These trucks used the separate M.C.B. cast-iron pedestals with drop equalizers and had outside bearings, and this general type was standard until the trend toward integral pedestals began.

The general use of clasp brakes and the need for easier inspection and quick replacements of brake parts brought about the introduction of the straight equalizer trucks. On this type of truck also it was possible by advances which had taken place in the molding art to cast the side bearings, cross bolsters and truck center in a unit, thus eliminating the separate side bearing arches on outside of frame.

Experience has conclusively proved that an equalized, swing-motion type of truck gives to passenger coaches a high degree of riding comfort, compensates for track irregularities, equalizes the load on the various wheels and provides insurance against derailment. The use of swing hangers, which provide a lateral mechanical cushion on curves and absorb the transverse blows on straight track, also tends to overcome the action produced by centrifugal force on curves. This is brought about by the inclination of the lower ends of hangers, permitting the wheels to move laterally of the vehicle body, the outer hanger swinging outwardly and upwardly and the inner hanger inwardly and downwardly, thus tilting the body toward the inside of curve when cars are going at high speeds. On the other hand, when standing or traveling at very low speeds on track in which the outer rail is elevated, the hangers work in the reverse direction, tending to maintain the car in a level position. This feature is also particularly desirable on heavily laden, high center of gravity vehicles, such as locomotive tenders, and it is believed its application could profitably be considered on other railroad rolling stock.

The corrosion-resistant quality of cast steel has been proved in the one-piece tender frame which, for more than 25 years, has successfully served in a place where are present sulphurous acid deposits caused by cistern leakage and coal spillage. An examination of any of these older cast-steel tender frames shows that they have been practically unaffected by this destructive agent. Probably the best example of the ability of cast steel to withstand corrosive deterioration is in the one-piece sulphur car underframes which have been in use on the Santa Fe for over five years with splendid results. This is in distinct contrast to the built-up steel car which corroded rapidly from the sulphur lading.

The production of steel castings is rapidly becoming an advanced science. Difficulties that were formerly looked upon as unavoidable are today rapidly passing, if indeed they have not already vanished. In no branch of industry has the steel casting been more generally utilized than in railroad work and this is largely due to the encouragement which railroad men have given to the adaptation of the unitary principle in their rolling stock, coupled with their recognition of its inherent value.

Locomotive and Car Wheels

By C. T. Ripley,
Chief Mechanical Engineer, Atchison, Topeka & Santa Fe

Prior to 1900 the usual wheel for locomotive and passenger cars was the steel-tired type similar to the European practice, and the old design double-plate or Washburn type cast-iron wheel was the usual standard for freight cars.

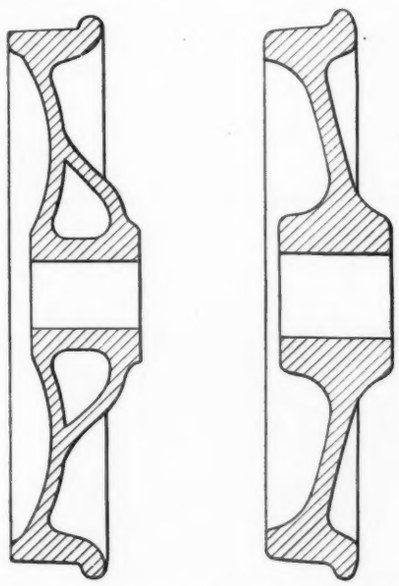
About 1901 machinery was developed for the production of the one-piece steel wheel known as the wrought-steel or rolled-steel wheel. The advantage of this type over the steel-tired type was the lower first cost and the elimination of labor involved in renewal of tires on centers. An additional advantage lay in the elimination of possible failures due to breakage of tires through the bolt or rivet holes. This type of wheel rapidly came into favor and became the general standard for locomotive tenders and passenger cars and gradually came into use on many freight cars, particularly those of larger capacity.

Steel Wheel Developments

Some locomotives built since the war period have had such large tenders that the wheel loads have increased to over 30,000 lb. per wheel. These excessive loads combined with high speeds put such heavy duty on the wheel that some difficulties arose due to shelling out of the tread. To meet this condition manufacturers have developed heat-treating processes for the wheels which give a better quality of metal, particularly in the tread. Elaborate plants for this heat treatment are now installed in most of the mills, and wheels of this type are being extensively used, particularly under locomotive tenders.

In the case of passenger-car wheels the difficulty which developed under the heavy braking involved in higher speeds was thermal cracking of the treads. Heat treatment alone did not appear to remedy this trouble, but the usage of a somewhat different steel and new processes of heat treatment appear beneficial. A new standard tread contour, with straight taper, has also proved helpful.

A special rolled-steel freight-car wheel, known as the "one-wear wheel," has also come into use, particularly on certain eastern roads. The object of this wheel is to afford a lower first cost and to eliminate the necessity for turning. The so-called two-wear wheel has been used to a certain extent, but not extensively.



Car Wheels—Old and New. Sections of the Washburn Wheel of 1898 and the New A. R. A. Single-Plate Wheel

All of these developments of rolled-steel wheels have been brought about mainly through the research work which has been carried on in the manufacturers' plants. The Wheel Committee of the American Railway Association has co-operated in this work and helped through service tests. The modern American rolled-steel wheel has no similar equal for quality in any other part of the world. Active experimental work is still going on.

About 1907 a new wheel of the cast-steel type, known as the Davis wheel, was developed. The steel in this wheel is an alloy with special heat treatment. It was originally of the one-wear type, but has recently been developed also in the multiple-wear type, as tool steels have been found which will turn its very hard tread.

The Single-Plate Chilled-Tread Wheel

The cast-iron wheel has also been extensively improved during the past 15 years and the present-day cast-iron wheel, or, as it is now officially called, "chilled-tread wheel," is a far better product than that formerly produced. The first change made about 1918 was the development of the so-called arch plate type which eliminated the sharp juncture of the two plates, which had been a point of weakness due to localization of stress and the possibility of collection of dross, etc. The next major development was the single-plate wheel. This design provided a concentration of the metal in a single plate, making the wheel much more resistant to plate breakage caused by heat developed by the brake shoe. At the same time the flange was thickened and the so-called reinforced flange standardized.

The single-plate wheel was adopted by the American Railway Association in 1928 and is now in general use. Its use has resulted in practically eliminating the so-called cracked plate failure which was a major difficulty with the old type of wheel. It has also greatly reduced flange failures and, in general, has been one of the most marked improvements in freight-car equipment during the past decade. Experiments for improvement of cast-iron wheels are still going on, particularly in the use of somewhat different alloys, to reduce the tendency of brake burn. The development work on the cast-iron wheel has been handled in the laboratories of the various wheel companies under the direction of their association. The A. R. A. committee and the individual railroad staffs have co-operated actively in this research work and carried on the necessary service tests to develop the new designs. Here again is a product which has no equal of its kind in any other part of the world.

A new development in wheels during the past two years has been in the usage of rubber, the object being to give easier and quieter riding. This development has been along two lines: One, to use pneumatic tires applied to steel centers with a steel flange; the other, the placing of rubber between the steel rim and the steel center. These developments are too new to warrant giving them a definite rating for railroad service. At best their field for application is rather limited, but they may prove to be of some advantage in certain light service.

The spoke-type driving-wheel center has been the only one used until recently new designs of the disc or semi-

disc type were developed. These have not been extensively used as yet, but numerous experimental applications have been made. The advantages expected in this design are greater strength, lighter weight and better counterbalance.

Locomotive trailer wheels are generally of the steel-tired cast-steel-center type. In recent years the manufacturers have developed their equipment so that they can produce rolled-steel wheels of large enough diameter for this service. Many such wheels are now in service and appear to be an economical and reliable substitute for the steel-tired type.

Wheel work involves about 20 per cent of the total car-repair costs and it is, therefore, an item on which the railroads should concentrate to make savings. Through the Wheel and Axle Manual the American Railway Association has actively assisted the various railroads in their efforts to improve wheel-shop practice, and large savings have actually been effected on the majority roads.

Passenger-Car Developments

By Peter Parke,
Chief Engineer, The Pullman Company

Interior of a Pullman Car of 1893

At the Century of Progress Exposition, under the dome of the Transportation Building, there is exhibited a replica of a sleeping car of 1859 and alongside of it, an all aluminum Pullman of 1933. A casual examination, nothing more, is needed to impress upon the mind of an observer the great progress made in the art of passenger-car construction.

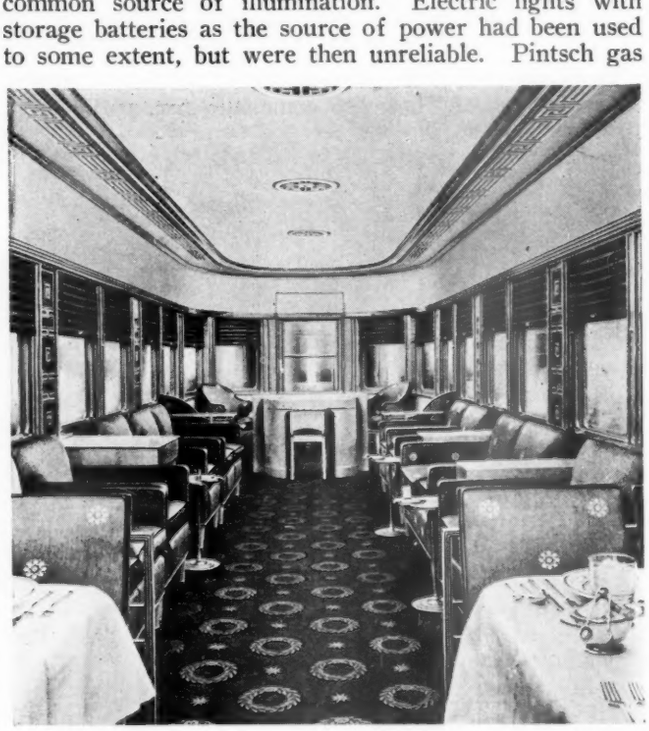
Car-body construction has undergone complete transformation. In the early days cars were constructed of wood throughout, with truss rods for support of structure between trucks. Cars were simple to design and build in those days and not subjected to many engineering considerations. Today, a steel car is an engineering structure which requires careful calculation and elaborate detailing. The development of the steel car was prompted by a due regard for the safety of passengers in long trains operated at high speed. The wood cars involved a fire hazard and often failed as protection for occupants in case of wrecks. The first step in the developments from which a steel car evolved was to introduce steel to strengthen the wood car. Bolsters and platform members were made of steel; next, complete continuous steel underframe members were introduced, also steel reinforcement as anti-telescoping devices for vestibules, and finally evolved the all-steel car, with which fire risk is eliminated and safety promoted. It affords an effective protection in train wrecks in all except isolated cases of exceptional severity. Incidentally, the steel car development resulted in the creation of a new industry, that of steel cabinet making for producing steel interior finish and steel furniture.

When the narrow vestibule was still comparatively new, I participated in the development of the first wide vestibule, which was an important contribution to the safety of railroad travel. Its outside and inside heavily reinforced walls, form a rampart which in collision receives and, by distortion and buckling of its framing members, absorbs the initial impact shock without damage to occupied car space. The paramount consideration in steel car design is safety.

Decoration and interior design has ever been one of constant variation in conformity with contemporary tendencies. From crude it developed into ornate and again back to simplicity. In various periods it has changed back and forth between the two extremes.

Lighting and Heating

When I first knew passenger cars, oil lamps were the common source of illumination. Electric lights with storage batteries as the source of power had been used to some extent, but were then unreliable. Pintsch gas



Simple, Dignified Comfort Characterizes the Latest Aluminum Pullman Cars

replaced the oil lamps. Improved electric light equipment was produced and a combination of Pintsch gas and electric light fixtures were used with a dynamo in the baggage car as the source of electric power for lighting the train. The practice of using combination lighting fixtures was continued during the development of reliable electric power equipment until the latter was dependable. Important in car lighting has been the generator and lamp regulator development, without which satisfactory illumination under the greatly varying train speeds is not possible. Batteries suitable for railroad car service are also a special development.

A common method of heating cars in my early experience was with a coal-fired, hot-water heater on each car, or hot-water jackets under the car for heating the circulation water with steam from the train line. Heating system developments were many and varied, and finally resulted in the general use of what is known as the vapor system of steam heat which comprises a number of regulating valves in which trainline steam is expanded and admitted under atmospheric pressure to the interior heating pipes, under control of a thermostatic disc in the drip end of the regulator. The vapor system is a safety development, as it eliminates pressure steam from interior heating pipes.

The sanitary facilities in passenger cars have kept step with modern development of plumbing for homes. All plumbing fixtures for railroad cars constitute, in construction details, a specific development for railroad service.

Open windows for ventilation were the only means available in the early cars. Later, scoop intakes were tried on the car roof for forcing air through ducts into the car. Either scheme produced good ventilation at times, but not so good in inclement weather, or when smoke surrounded the car. Deck exhaust ventilators were later devised, which, when the train is running, create a low-pressure area inside the car, thereby causing infiltration of air in fine streams around windows and doors.

The latest development is air-conditioning equipments for both summer and winter use. With air-conditioning equipment, fresh air is drawn into the car, filtered and delivered under pressure to the air-conditioning equipment where it is cooled and dehumidified, or heated and humidified, as the occasion may require, and then delivered to the car, all operations performed under full automatic temperature control. Several types of effective air-conditioning equipments have been developed for cooling with ice, with water evaporation, with steam from the trainline, and by mechanical refrigeration in which the compressors are driven either by electric motor or direct from the car axle through speed control.

Railroad passenger transportation equipment of today has been developed not merely to provide space for a passenger to occupy while being transported from one place to another, but as a safe vehicle in which are provided commodious living quarters, sleeping accommodation in dormitory space, or in various types of private rooms, provisions for baths, club facilities, and now fully air-conditioned equipment for maximum comfort both in summer and winter.

Automotive Engines and Cars

By L. G. Coleman,
Manager, Locomotive Department, Ingersoll-Rand Company

In view of the relatively low thermal efficiency of the steam locomotive and the considerable expense of the auxiliary services to maintain it, many have wondered why the internal combustion engine, with its much greater thermal efficiency and practically complete absence of necessity for auxiliary services, such as coaling plants, water and cinder stations and boiler washout facilities, has not made more headway on the railroads. The history of railroad research and development in the use of internal combustion engines shows that the railroads have been alive to the situation from early days.

The application of gasoline engines to unit passenger-car movements was begun in the early nineties and had reached a very considerable development by 1912, but it was completely interrupted by the necessity for all manufacturing plants to turn to war material. Just before this happened the possibility of complementing this development by the addition of Diesel engines for heavier powers was being given consideration, but this effort also had to be dropped.

After the war this development again became active. It was necessary to make radical changes in theories of Diesel engine design before they could be successfully adapted to locomotives. The ability to build engines for locomotives of any size and capacity required had barely been accomplished when the cataclysm of 1929 again called a temporary halt.

In spite of these difficulties, on December 31, 1932, there were in service, or ordered, outside of the United States and Canada 159 oil-electric locomotives varying in size from 200 to 1,700 hp. and 63 oil-electric rail cars. There were in service in the United States and Canada 127 oil-electric locomotives, 11 gas-electric locomotives, 32 oil-electric rail cars, and 737 gas-electric rail cars.

Adapting Operating Methods to the Diesel Locomotive

The engineering problems overcome in the design of Diesel engines for locomotives are only the first step. Even under the most favorable conditions individual Diesel locomotives must cost more than steam locomotives. In order to obtain sufficient return on the investment to warrant their full application, certain material alterations in operating methods are essential. The operating characteristics and duty cycle of steam and internal-combustion engines are different, mainly due to the direct relation of speed and horsepower in the former and the constant available horsepower of the latter, as well as their freedom from service stops. The most favorable operating tonnage should be determined and then the proper horsepower applied rather than the reverse method which has largely been used in the past.

Diesel locomotives may be applied one at a time and operated with steam locomotives, their installation being spread over a period of years. Only a portion of their economies are gained, however, until the complete application is accomplished. These economies, both direct and indirect, are so great that it seems inevitable their use will be undertaken when conditions become more stable.

The essential limitations to which Diesel engines in railroad service are subjected are such as to require special design for that service. They must be relatively

light and small, radiation capacity is limited, and at the same time they must be reliable and able to run for long periods with no expert attention.

In stationary and marine service, weight and size are relatively unimportant and there is no necessity to transport the cooling medium. The engines have the advantage of being under constant supervision by expert mechanics. In air service weight is of prime importance and continuous service requirements short. Expert supervision is available after each trip. Long life, while desirable, is not essential. The ideal railroad engine must have the good points of both and the weaknesses of neither. In order to get the full benefit of Diesel operation, the units should be capable of remaining in service for at least six days with no other attention than fueling and safety inspection; should not require general overhaul oftener than once in twelve months, and should be capable of giving 7,000 hours of actual service in a year.

The development of light, high-speed Diesel engines for buses, trucks and aeroplanes has led in some quarters to the expectation of the early application to rail service of such engines somewhat modified. I am of the opinion that this is not probable. While some increase in rotative speed and lighter construction will probably come, in view of the limitations I have pointed out, it will, of necessity, be by slow degrees and require engines specially designed for rail service.

Locomotives capable of duplicating the performance of steam locomotives in passenger and freight service today can be built with Diesel engines as now designed and building. If full advantage is taken of their possible economies, they will justify their present relatively high cost. This handicap will, of course, lessen as they are built in quantities.

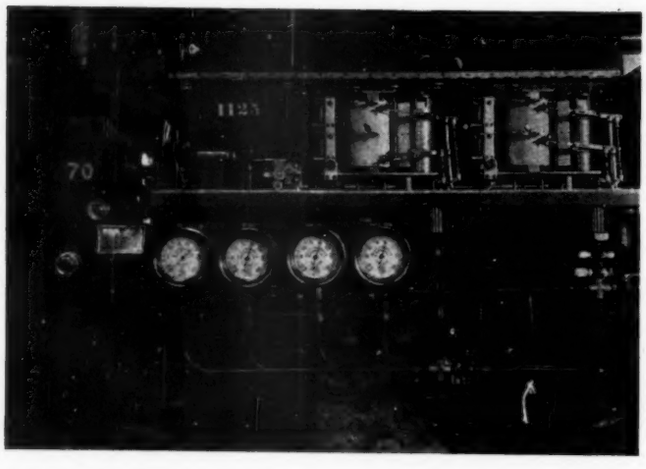
It is possible to build a 4,000-hp. Diesel electric locomotive with Diesel engines now built and running with 55,000 to 60,000 lb. on the drivers, and I believe the next few years will find them entering the field of main-line operation in considerable numbers.

Research in the Railroad Braking Art

By Samuel W. Dudley,
Professor of Mechanical Engineering, Yale University

Michael Reynolds, writing in 1862 of the system of continuous brakes then in use in the United Kingdom, opens his book with the question "What can be done to prevent fatal accidents?" Suppose we ask, in 1933, "What has been done?" One answer appears in the railroads' report to the Interstate Commerce Commission on last year's passenger traffic. *Not a single revenue passenger lost his life in a train accident* for a total of nearly seventeen billion miles traveled by passengers in the year 1932. This unique record is impressive testimony to the farsightedness, persistence and ability of those who, whether from within or from without, have guided or contributed to the safety factor in railroad progress.

What has been the relation between the railroads (the users) and the manufacturers (the providers) in the development of new facilities to meet the new demands of an expanding transportation industry? Has progress in the art of railroad braking anticipated or awaited the insistent demands of operating requirements, progressively increasing in severity? Which of the interested parties—the railroads, the manufacturers, the public—have assumed the initiative?



One of 38 Trainagraphs in the Power-Brake Laboratory at Purdue

All of the agencies mentioned have contributed their share in varying degree, at successive stages and according to the circumstances of each progressive step.

The railroads, responsible both for conducting the business and practicing the art of transportation, have always been alert to the interdependent physical and economic conditions confronting them. In this country they have developed facilities for and programs of joint action among themselves in order to meet the demands of their own individual operating requirements, or surrounding competitive conditions. At the same time both the individual and the associated railroads have recognized their dependence upon the manufacturers furnishing the means for accomplishing the results desired. Not being manufacturers themselves, nor, as a rule, staffed with experts in the field of air-brake engineering or design, the railroads have naturally looked to the manufacturers and their technical experts for assistance in these problems.

The manufacturers, by keeping in touch both with local and country-wide requirements, have been able to bring their resources of intensive and extensive studies and experience to bear upon operating problems developing locally or nationally. The co-operation between the air-brake manufacturers and the railroads, fortunately for the safety and economy of railroad operation, has been close and intelligent. From the beginning the relationship has been more that of consultant and client rather than that of mere buyer and seller. To his problems and responsibilities as the builder of a product for sale the manufacturer has added no small share of his clients' responsibilities for the use of that product to safeguard the life, the property and the economic values of the traveling, shipping and investing public.

Transportation is both a business and an art. The technique required for conducting and developing the business of transportation draws heavily upon the material available and the principles established in the underlying fields of commerce, economics, finance and the political and social orders through which they operate. In the practice of the art, as is the case in the business of transportation, there are available the tools, the facilities and the principles evolved in related and

contributory fields, such as science, engineering and manufacture.

It is the business of the engineering and manufacturing agencies interested in the railway field to provide the materials, tools and facilities needed from their particular industry to develop the principles upon which sound economic progress in these directions may safely proceed and to organize and carry forward the basic scientific and technical research that will contribute most fundamentally and effectively to such progress.

It would be impracticable for the railroads themselves, burdened with their responsibilities for conducting the business and practicing the art of transportation, to carry the vast and multifarious burden of technical research and organization now so well provided by individual manufacturers in their special fields. But it has always been true, and always will be true, that only by the closest co-operation between the railways and such organizations can sound progress be insured.

The requirements are first evident or foreshadowed in railroad operation or trends. Analysis, research, experiment and development by the manufacturers result in apparatus and methods to which the railroads must then apply the final test of road trials and service operation. Fortunately for the business, as well as for the art of transportation, this common understanding of their joint and individual responsibilities has been recognized and mutually fostered from the beginning. There is no more vitalizing and effective element contributing to the progress of this vast and essential industry than its informed and co-operative approach to its technological problems.

Progress in the Development of Draft Gears

By L. P. Michael,
Chief Mechanical Engineer, Chicago & North Western

Since the adoption of the automatic coupler there has not only been a continuous study, research and development of the coupler and its parts, but there also has been a continuous development of cushioning devices, or draft gears, as well as of the attachments to the framing of the cars.

Draft-gear development has a very important mechanical and economic significance in American railroading. Its dependable performance under all service conditions is virtually essential to the preservation of lading and the perpetuation of the life and the usefulness of car structure. Its dependable performance also contributes very materially to the safe operation of trains and the speeding up of traffic.

Until about 1890 when the automatic coupler was coming into general use a single helical spring afforded a fair degree of protection, because the cars were of only 10 to 20 tons capacity and trains were short. The use of a car connector, which automatically coupled by impact, speeded up yard movements and permitted the handling of longer and heavier trains with larger and heavier locomotives. Car weights and capacities at this time also were increasing. All of these conditions were particularly destructive to cars with the conventional wooden sills and trussed wooden superstructure, and this type of equipment had a hard time of it in the early days of the automatic coupler. These conditions were the stimulus to the development of better draft gears and attachments.

The destructive tendency of high speed switching also hastened the advent of cars of steel construction. The steel car had none of the body resilience peculiar to the flexible wooden car which was very effective in absorbing shocks. The friction type of draft gear was the logical solution of the problem of restoring this lost resilience. In 1897 the first friction draft gear was introduced as a practical device. Since then much constructive thought has been exerted in this field of design, as is evidenced by the large number of draft gears and attachments which have been developed.

Draft-Gear Requisites

The draft gear is essentially an engine, because it reciprocates against resistance and does work during a compression and release cycle. The action is identical, except that the cycle is reversed. The cycle of action for the best performance in railroad service must conform to about the following fundamentals:

(1) Development of the required capacity under high-speed compression with prescribed limits of stroke or travel.

(2) Maximum utilization of the initial part of the compression stroke for work development so there will be no slack action and so the pressure at the end of the stroke will be as low as possible —the lower this pressure the better the quality of shock protection of given capacity.

(3) Low-pressure release so the absorption of harmful impact energy as frictional heat will be as high as possible and the return energy or recoil as low as possible consistent with proper release.

(4) Maximum endurance or long-term maintenance of adequate capacity cycle, without change in qualities of low final pressure and low recoil effect with proper release action.

(5) A sturdiness of column structure which will accommodate overloads with a minimum of set and without in any way impairing the capacity and endurance functions of the device.

(6) Automatic adjustment for wear and column set for the prevention of slack.

The present railroad economic situation not only demands these characteristics at a nominal cost, but it also requires their provision with the least possible number of parts and least total weight.

The first comprehensive road and laboratory tests were made by the M. C. B. Draft Gear Committee in the years 1900, 1901 and 1902. A 1,640-lb. drop hammer and a 300,000-lb. capacity screw-compression machine constituted the laboratory equipment and gave results which were not consistent with service performance. The screw-compression machine imposed an action many times slower than actual service conditions, and the 1,640-lb. hammer, commonly used to test axles and wheels, had a striking velocity at draft-gear capacity so high as to produce unsatisfactory results. However, laboratory practice has greatly improved with time. The slow compression machines were gradually discarded and the hammer weights increased, with successful results, to 9,000 lb. and later to 27,000 lb., so the service performance today can be faithfully interpreted by accelerated laboratory tests.

Advanced Methods of Investigation

Interesting and valuable methods of determining details of draft-gear performance have been devised, such, for example, as the chronograph which accurately determines the pressure cycles of draft gears during com-

pression and release peculiar to railway shock-resisting service.

Ultra high-speed motion photography has been used to excellent advantage for the purpose of revealing the phenomena of car impact, and the actual performance and behavior of various parts of the draft-gear mechanism. Slow-speed motion pictures of these photographs permits observation for longer than a minute of actions which were completed in less than a second.

All through the years since the time the Master Car Builders' Association was organized in 1867, even through and immediately after the war period, constant research and development, laboratory, car-impact and road tests have been in progress or under consideration by the American Railway Association, co-operating with the manufacturers. This continuous program of co-operative action has recently culminated in the A. R. A. standard specification for freight-car draft gears, which sets up minimum standards for draft-gear performance. Manufacturers of railway draft gears must now obtain a certificate of approval of their products from the American Railway Association which has installed a valuable research laboratory at Purdue University for the purpose of testing draft gears submitted by the various manufacturers to make sure that such gears as tested will meet all the requirements of the A. R. A. specifications.

This procedure will unquestionably be of great benefit to the railroads and afford the very much needed basis of comparison and guidance for draft-gear construction.

Research Related to Locomotive Development

By W. E. Woodard,
Vice-President, Lima Locomotive Works

Upon first thought the relation and influence of scientific research on locomotive development may appear rather difficult to define and trace. To many persons the steam locomotive has seemed to just grow one step upon another—apparently to some degree the result of trial-and-error methods. This view undoubtedly results from the fact that improvements in railway motive power, before obtaining any general acceptance, must not only produce the purely theoretical results forecast for them, but they must also meet the exacting requirements of safety in train operation and must demonstrate their advantages in operation under widely varying conditions. Moreover, any changes introduced must prove to be sound economic investments, or produce benefits in some other operating phases to offset their increased first cost and their maintenance.

I will cite a few examples which seem to amply justify the statement that fundamentally much of the outstanding progress is traceable to and based upon technical research work.

First, referring to materials of construction. In this field the designers have availed themselves of a vast amount of technical study on metallurgy, particularly the effect of various alloys on steel used in locomotive construction.

In the matter of train resistance a most interesting and important amount of research work has been performed. Its bearing upon motive-power development is evident in connection with the recent steps being taken in the streamlining of equipment and in light-weight construction.

A whole paper could be written upon the history of research on train resistance, dating back to the studies of D. K. Clark in 1855, Wellington in 1887 and Goss in 1889, whose contribution on air resistance was the result of elaborate laboratory tests upon models. Those interested in the subject will find a very complete bibliography in the library files of the American Society of Mechanical Engineers in New York, prepared by F. J. Cole in 1909, which contains references to all the work done upon the subject up to that date. In 1910 and 1912 appeared Schmidt's formulas based upon the University of Illinois tests which have been largely used as references up to the present time. In 1915 the Pennsylvania contributed a valuable addition to the subject in its test bulletin No. 26, and in 1916 and 1918 the University of Illinois added their bulletins upon the resistance of electric cars and railway coaches. The data developed formed one of the foundations upon which railway men and locomotive designers rate the capacity of their existing motive power and predict the performance of comtemplated designs.

The locomotive designer is much concerned with the

A Locomotive Exhibited at Chicago in 1893

proper proportioning of the furnace, boiler and superheater to the steam-using or engine portion of the locomotive. An outstanding contribution in this field was the work of F. J. Cole, who in 1914 proposed his locomotive ratios. I know that this was a piece of work involving real research and study, as at the time Mr. Cole was assembling the data upon which his calculations were based I was closely associated with him. The locomotive industry and the railways have benefited greatly from this work and it has been only within the past few years that advances in the art have modified the characteristics of the steam locomotive so as to place many of the modern designs outside the range of his figures and ratios. However, the general method of approach he developed and used is still applicable to the problem and his work still stands as an outstanding piece of research in the railway field and is a guide upon which all locomotive designers depend.

The contributions of the various locomotive test plants to research work has already been commented upon. In this connection it need only be mentioned that one of the handbooks of the locomotive designer is the set of Pennsylvania test-plant bulletins. Another piece of research work—possibly not so well known but of great value to the designer—is the standing boiler tests run by the New York Central at Gardenville in 1923.

Special Investigations for Advanced Designs

Locomotive designs do not just grow. In the preparation of the basic design of the 2-8-4 type locomotive, known as the A-1, built by Lima in 1925, it was desired that the proportions of the boiler be based upon a maximum coal rate of about 100 lb. per sq. ft. of grate per hour, but we found that little direct data were available for predicting how such a boiler would perform. The proportions and dimensions to which the final boiler was built were worked out from assembling, comparing and extending data from the Pennsylvania test-plant bulletins and the Gardenville standing tests to which I have already referred. These figures were checked by comparisons and calculations from numerous road tests. The boiler proportions finally selected led to the use of a four-wheel trailing truck, which has now become practically standard for heavy freight and passenger locomotives.

It was further desired in the design to use cylinders in which the maximum cut-off was limited, in order to obtain high horsepower outputs for a given driving-wheel weight and to reduce steam consumption per unit of work. Certain features of limited cut-off locomotives were not predictable at the time. Through the hearty co-operation of the New York Central a series of starting and acceleration tests were run at Ashtabula in 1923, from which some very valuable data were developed and upon which the proportions and cut-off of the cylinder of the A-1 were based.

Early in the work on this design we had to face the problem of providing rods capable of handling increased horsepower output and heavy piston thrusts. This problem was answered by designing and applying to an existing locomotive a set of experimental rods of the type which later became known as the Tandem rod drive.

After the locomotive was constructed eight different railroads heartily co-operated in road tests. These tests, primarily for demonstration purposes, nevertheless developed much technical information which has proved very useful in applying and extending the same principles of design to other and larger units.

These examples of research are selected simply as illustrations showing that, after all, scientific investigation has played a vital part in the development of the modern locomotive.

The Locomotive Boiler

By H. B. Oatley,
Vice-President, Superheater Company

The increase in size and power of the steam locomotive has been the subject of many papers and discussions during the past several years. Comparatively little emphasis, however, has been laid upon the fact that, without the development of a more economic steam generating system in its entirety, the greatly enhanced value of the larger locomotives would not have been realized.

Much intensive study and research has been put upon the problem of making available, for the locomotive cylinders, a working medium, greater in quantity and more suitable in quality; a medium which would permit more foot-pounds of work delivered by the cylinders from a smaller number of B. t. u. in the fuel supply.

That this objective has been attained is amply attested by the steadily decreasing steam and fuel rates per indicated horsepower-hour. Recognition must be given to the greatly increased sustained boiler horsepower which has been the factor contributing most to the greater ton-miles-per-train-hour performance that has been an outstanding achievement in American and Canadian railroad operation.

The table indicates the change in boiler characteristics during the past 30 years. The values for steam pressure, degrees of superheat and pounds of steam per hour are not the maximum, but represent what was considered good conventional practice at the particular period. Boiler capacities very much above these figures have been provided; passenger locomotives with an evaporation of 86,000 lb. and freight locomotives with an evaporation of 122,000 lb. per hour have been in use.

The increased output per pound of boiler, boiler water and superheater represents the advance in effectiveness. This, for passenger locomotives, is an increase of 70

Changes in Boiler Characteristics During the Past 30 Years

Year	Steam press. (lb.)	Superheat, deg. F.	B.t.u. per lb. steam	Lb. steam per hr.		B.t.u. per hr. in thousands		Wt. boiler and sup'h'r with two gages of water		B.t.u. per hr. per lb. boiler, water and superheater	
				Pass.	Frt.	Pass.	Frt.	Pass.	Frt.	Pass.	Frt.
1900	180	...	1,198	23,200	35,000	27,793	41,930	70,000	85,000	397	493
1905	200	100	1,260	32,000	38,000	40,300	47,880	80,000	92,000	504	520
1910	200	150	1,287	37,000	47,000	47,600	60,500	88,000	104,000	541	581
1915	200	225	1,326.5	39,000	53,000	51,700	70,300	97,000	120,000	533	585
1920	210	225	1,327.9	48,000	62,000	63,700	82,300	107,000	136,000	595	605
1925	225	250	1,343.0	52,000	71,000	69,800	95,300	117,000	155,000	597	615
1930	250	300	1,373	63,500	82,000	87,190	112,600	128,000	175,000	680	643

per cent and, for freight locomotives, 30 per cent, in the same period of time.

The major factor, not only in boiler design but also in respect to the energy supply for the cylinders, has been the integrally built superheater. While the advantages of superheated steam have been most pronounced in cylinder performance, it should be remembered that the present-day horsepower requirements could not have been met with boilers that supply only saturated steam.

Feedwater heaters have contributed, but to a somewhat lesser degree, in supplying greater sustained horsepower from a boiler of given size.

The trend toward the use of steam at higher pressure and temperature, together with the need for greater capacity, brought to the front the advantages of the present-day form of smaller flue superheater. Structural and material questions were considered in this design. The objective of greater heat-absorbing capacity of the combined boiler and superheater made possible higher temperatures for larger evaporations within a boiler of any prescribed diameter.

Notable increases in the firebox surfaces not alone caused by the increase in grate area, but by the addition of combustion chambers, thermic syphons, arch tubes, etc., have brought beneficial results in firebox and combustion-chamber efficiency. Increased capacity has resulted from stoker firing, improvement in grates and in more effective front-end draft appliances.

In the matter of materials mention must be made of the reduction in weight afforded by the use of alloy steels for shell plates as well as for fireboxes. In construction, the use of welding has effected some weight reduction, but to an even greater extent has decreased the cost of maintenance. Consideration in recent years has been given to the use of seamless drums and boiler shells and further use of such constructions may be anticipated.

The locomotive boiler has greater possibilities and designers in this country, as well as abroad, are giving intensive study to its further development. Conventional boilers with stayed surfaces are in satisfactory service up to 300 lb. per sq. in. in this country and some have been recently placed in service abroad carrying 385 lb. per sq. in. working pressure.

The increasing use of higher steam pressures has for many years caused thought to be given to the water-tube firebox. The Baltimore & Ohio and the Delaware & Hudson have gone further in this direction than other roads in this country. Water-tube fireboxes for pressures running from 250 to 500 lb. per sq. in. are in service. More information as to their performance will prove of value and point the direction for further study and research.

Working in the direction of still higher boiler pressures, and with the aim to eliminate the possibility of scaling condition on firebox surfaces, a great deal of research and experimental work has been done leading up to the construction of several locomotives with the multi-pressure boiler. Two of these—one on the Canadian Pacific and the other on the New York Central—have been under severe service and test conditions for more than a year.

Locomotive Running Gear and Counterbalancing

By A. G. Trumbull,
Chief Mechanical Engineer, Advisory Mechanical Committee, Chesapeake & Ohio, Pere Marquette, Erie, and New York, Chicago & St. Louis.

With increased freight-train speeds the influences of the unbalanced revolving weights upon the track, the structures and the locomotive themselves have assumed such importance as to arouse universal interest on the part of engineers and others concerned in locomotive design and operation. In the more recent notable examples of locomotive construction in this country freight locomotives have been built with much larger driving-wheel diameters, thus affording an opportunity to balance not only the revolving weights, but also the usual percentage of reciprocating weights.

More recently, however, the increasing popularity of airplane travel has led to the consideration of much higher speeds for steam locomotives than has heretofore been considered possible. This again aroused a new interest in the counterbalancing problem, the solution of which is an obvious prerequisite to speeds approximating those which are now attainable with electric locomotives or with certain projected types of rail cars to be operated with internal combustion engines.

There have been a number of recent novel developments, both in design and in the application of materials, which promise important and even revolutionary results in the solution of this problem. The more important of these are the following:

Increased Counterbalance Capacity

The more recently established practice in the design of driving-wheel centers contemplates the use of open counterbalance pockets, permitting the introduction of a maximum weight of lead alloy. However, in the case of many older types of locomotives, this is frequently insufficient to provide for the proper balancing of the revolving weights and, to meet this problem, the Lima Locomotive Works has developed an improved type of counterbalance which, as to old equipment, involves the application of a plate on the inside of the existing counterbalance, the necessary clearance being provided by a modification in the spring rigging through which the outside face of the conventional type of driving-box saddle is eliminated, the spring being carried on a suitably designed saddle overhanging the driving box from the inside.

A recent application of this arrangement to two locomotives of the 2-8-4 type, both of recent and exactly the same design and characteristics, has been made. As built, the locomotive had a deficiency of 136 lb. in rotating balance at the main wheel. With the same type of locomotive equipped with the improved counterbalance, it was possible to balance all of the rotating weight and the proper proportion of the reciprocating weight. This resulted not only in substantial reductions in rail pressures at all speeds, but also in more even rail stress curves, indicating a great improvement in the influence upon the track and locomotive over the effects previously produced by a large excess of revolving masses.

In addition to the common alloys of nickel and chromium, there has been considerable research in the possibilities of aluminum, especially for those reciprocating parts which are not subjected to high temperatures. Evidence is accumulating which indicates that satisfactory operation may be expected from these parts and

that a weight reduction over steel of at least 50 per cent may be anticipated.

Special Steels and Roller Bearings

The most notable pending developments in the design of the revolving and reciprocating masses are those contemplated in the researches of the Timken Roller Bearing Company. These involve radical departures in design and materials and are naturally associated with the use of roller bearings, of which the Timken Roller Bearing Company is an advocate for locomotive service. Reductions in the weight of reciprocating parts approximating 50 per cent are considered possible through the use of Timken High Dynamic steel coupled with a suitable design of rods, crossheads, pistons and piston rods to utilize this steel efficiently. High Dynamic steel is represented as a natural alloy of carbon, manganese, chromium, nickel and molybdenum and responds to heat treatment developing properties that are unapproached by other alloys or steel available for similar purposes. This steel has the following physical characteristics:

Yield point	120,000 lb.
Elongation	20 per cent
Reduction in area	60 per cent
Izod value	50 to 70

It will be observed that the ductility is comparable with ordinary carbon steel, but that the resistance to shock as represented by the Izod value is many times greater. The main rod of the proposed design is about two-thirds the weight of the conventional plain-bearing rod. The main and side rods are distinguished by relatively large bores to receive the bearings and by the rod ends having a hub, disc and outer rim, providing maximum strength and resistance to distortion with minimum weight. The section of the rod bearing is relatively narrow and deep as compared with the plain bearing, which is relatively wide and shallow. The distribution of weight of the Timken rod end is approximately sixteen times more favorable than a similar rod with a plain bearing.

The crosshead has two full roller shock-type Timken bearings which are mounted in the crosshead forging of High Dynamic steel. The driving stresses will be transmitted through a continuous train of High Dynamic steel construction permitting the use of aluminum alloy crosshead gibs, thus effecting a further reduction in the weight of reciprocating parts. The gib is carried on pivot plates, which are pivoted through bronze bushings on the crosshead forging. The crosshead key is to be made of High Dynamic steel of I section, which will effect a reduction in weight of 40 per cent.

The piston rod will be forged from cold drawn High Dynamic steel tube with large bore, permitting the use of a ¾-inch wall. It will be about 62 per cent stronger than a solid axle-steel forging and will be approximately one-half the weight. A piston has been designed for a 27-in. cylinder of 250 lb. steam pressure, having a weight of 133 lb. This is estimated to be about 40 per cent of the weight of the built-up piston and reduces the weight of reciprocating parts accordingly.

Designs which have been developed for a Pacific type locomotive indicate a reduction in weight of reciprocating parts approximately 50 per cent of the conventional locomotive, which is about two-thirds that heretofore obtained with an American locomotive designed with particular reference to minimum reciprocating weights. Current American practice provides for an overbalance of 50 per cent for reciprocating weights. Since the reduction in weight through the Timken development is 50 per cent, a locomotive with Timken rods and reciprocating parts could be operated with the revolving parts only balanced, so that at comparable speeds no greater nosing effect would be produced than with the present conventional design. It would be possible, therefore, to very greatly reduce the dynamic augment and effect a corresponding reduction in the influence of stresses on track and on locomotive parts, such as boxes, frames, springs, spring hangers and equalizers, which should produce substantial economy both in maintenance of track and of equipment.

Locomotive Valves and Valve Gears

By G. S. Edmonds
Superintendent Motive Power, Delaware & Hudson

To date, three practical types of valves have been developed, in their order, the slide, the piston and the poppet. The definite date of the first use of the slide valve is not fixed, but it is known Murdoch of England, Watt's assistant, used a crude form in the latter part of the eighteenth century, which was later materially improved by Watt.

In the earliest examples of British steam locomotives, steam was admitted to the cylinders throughout the full stroke of the piston and the provision of either notch plates or loose eccentrics made it possible to simply reverse the locomotive without any further thought as to the use of the expansive properties of the steam. It soon became apparent by limiting the amount admitted to the cylinders the propelling force acting on the piston did not cease at once, due to the elastic nature of the employed fluid, and that for a given amount of work to be performed a substantial economy of fuel could be obtained by this limited admission. It seems certain that James in America was fully aware of this fact as early as 1832, and while the advantage of this construction was taken in the operation of stationary and marine engines, and though lead was provided, quite generally the practice of just sufficient lap to prevent direct waste of steam continued with the locomotive. This is probably due to the fact, with the increased lap, difficulty was experienced in starting heavy trains and evidently the easy handling was deemed more important in this period than the saving of the fuel.

In 1845 the independent cut-off valve was introduced, that used by Baldwin, consisting of a steam chest, divided by a horizontal wall into two chambers, the cut-off valves operating in the upper and being actuated by a separate gear to cut off the steam at almost half stroke.

As boiler pressures increased and changes became necessary to lighten the load on the slide valves, the next distinctive improvement being the development of so-called "balanced valves." The 1870 annual report of the Master Mechanics' Association gives 12 different forms of balanced and anti-friction valves. In the same year an improved balancing arrangement was patented by G. F. Morse and in 1880 this was further improved by George Richardson, greatly increasing its efficiency and winning popular approval. In 1893 the "Wilson American Balanced Valves" came into existence. These two practically covered the field.

The piston valve was first successfully used in the late eighties of the last century on some 2-4-0 type express passenger locomotives of the French State Railway. In America in the nineties it was used in the development of the compound locomotive. The introduction of the use of superheated steam at the closure of the nineteenth century, causing distortion and cutting of seats with the slide valve, quickly extended its use on new power and the substitution on many of the older types by the development of a universal steam chest. This valve continues to be accepted quite generally as the standard for the conventional locomotive of today.

The poppet valve, attempted by Watt, was first introduced on a commercial scale in the railroad field in 1923 on the Austrian Federal Railways.

Among their claimed advantages are:

1—It remains steam-tight over longer periods of service

2—Decreased wire drawing losses due to considerably increased steam-admission areas

3—Lower back pressure, as the exhaust takes place with greater facility due to improved passages

4—With higher pressures it permits the possibility of earlier and more economical rates of cut-offs

5—Decreased power necessary for operation due to decreased friction losses and lower lubrication factor

6—Possibilities of decrease of cylinder clearance volume

Their service in America has been distinctly limited and reference thereto will be made later.

In about 1849 Thomas Rogers applied for actual service the first link valve motion in this country, but its use was limited to a few locomotives. Until the year 1856 most of the Baldwin constructed locomotives had valve gears of other than the link type, but subsequent thereto this became the adopted gear for locomotives built at these works and quite generally in America.

The Walschaert gear was invented by the Belgian engineer, Egide Walschaert, in 1844.

The first outstanding application in the United States was that made by L. F. Loree in 1903 to the Baltimore & Ohio mallets. The success of this was such that its use rapidly followed in the United States. In 1908 the valve gear then known as the Baker-Pilliod was first applied to a locomotive on the Toledo, St. Louis & Western. This was further developed and subsequently superseded by the Baker valve gear patented in 1911, which is now in use on about 13,000 locomotives.

The poppet valve, if of the oscillating type, may be actuated by either the Walschaert or Baker gear; if of the rotating, by a gear box attached to the main driving shaft or connected to the main crank pin, an application of which may be examined at the Century of Progress Exposition, on the Delaware & Hudson locomotive "L. F. Loree."

While the generally-accepted practice for locomotives in the United States today is the piston valve with either the Walschaert or Baker gear, the question presents itself, what of the future?

In 1926, an oscillating-type poppet valve, actuated by a Walschaert gear, was applied to a Consolidation freight locomotive on the Delaware & Hudson to determine whether or not such was practical under American operating conditions. The superintendent of motive power was not optimistic as to its probable serviceability. In this he was happily disappointed. In 1927 he visited Europe, contacting in Italy Mr. Caprotti and in Austria the Lentz representatives. At the roundhouse in Florence, having access to the records, a check of three months' service of coal consumption, 15 piston versus 12 Caprotti, developed a finding of 9+ per cent favorable to the poppet locomotives. Riding between Florence and Rome, it was observed at 5-per cent cut-off, a free running locomotive was had. In Italy and in Austria encouraging service mileage figures were given from both the Lentz and Caprotti applications.

Returning to America, in 1929, there was designed by the motive-power department of the road and constructed at its Colonie shops, for the Albany-Montreal service, a Pacific-type, piston-valve locomotive with lowered center of gravity, accessories located with this thought in mind, and gadgets concealed. This locomotive is now having its first general overhauling with a mileage of 307,500 to its credit.

In 1930 a sister locomotive with oscillating poppet valves was built for comparative purposes and exhibited at the Atlantic City convention of the American Railway Association, Mechanical Division, in 1930. This locomotive has now to its credit 220,000 plus miles. Barring accident, its probable mileage before general overhauling will not be much different than that of the piston. When first placed in service, the speed factor was satisfactory, but the locomotive was seriously deficient in power. Accordingly, the intake valve was increased from 7 to 7½ in.; the exhaust valve, from 7½ to 8¼ in.; and the lift of the intake valve increased from ¾ in. to $^{13}/_{16}$ in., while that of the exhaust valve, ⅞ in. was not changed. The cylinders are 22 in. in diameter.

A Modern Locomotive Valve and Gear Arrangement

There is now very little to choose from between the two locomotives with reference to power and speed. Very careful tests were made over a period of 30 days each in passenger service with varying loads and the results had were somewhat favorable to the piston valve. As this was contrary to the theoretical possibilities, an exhaustive analysis was made developing the need of a reduction in the per cent of clearance volume and an improvement in the steam passages. This will be done when the locomotive is shopped and it is the judgment of the superintendent of motive power, such will change over the rating of the two locomotives. The service reliability and availability of the two locomotives are very good. A higher rate of craftsmanship is necessary with the poppet valve.

In the past decade, material increases have been made in the boiler pressures and steam temperatures of the normal locomotive. The full possibilities of the conventional boiler have not yet been attempted in the United States, our thought being that this rests somewhere between 350 to 360 lb. In Germany experiments are being made with approximately 350 lb. With the demands for higher speed in passenger service, and the possible need of a more active steam, probably higher

temperatures, with the present material somewhere around 850 deg. F., will receive consideration.

With the piston valve and Walschaert, or Baker combination, considering the foregoing, we are confronted with the economical use of the expansive qualities of the steam. Remembering the five-per-cent cut-off operation in Italy, it seems logical we are approaching the day in the United States when more serious consideration must be given to the development of the poppet valve with its possibilities to meet these conditions.

Locomotive Accessories

By C. H. Bilty,
Mechanical Engineer, Chicago, Milwaukee, St. Paul & Pacific

Recently there have been numerous attacks upon the railroads for lack of research. It is evident that most of the criticism is based upon a misunderstanding of the facts. The critics fail to recognize, or have overlooked, the fact that any consideration of research applied to railroad problems must include the research conducted by industries that supply equipment to the railroads.

For many years the aim of the designer has been to produce a locomotive that in every sense of the word could be called a power plant on wheels. Great strides have been made toward that goal. The best locomotives of today are not only far more powerful than those of 20 years ago, but the development and research in recent years have also been responsible for a very great increase in their efficiency. Today, a pound of coal produces from two to three times as much power in a locomotive as it did 20 years ago and the end is not yet in sight. However, few people seem to realize that the accessories indispensable to good central station practice are not easily applicable to the locomotive.

Without exception, every attempt to adapt an important power plant accessory to locomotive service has disclosed the fact that immediate application in the original form was impossible and that complete redesign was necessary to meet the severe requirements of locomotive restrictions and service. In many cases the redesigned accessory retains no more than the fundamental idea of its stationary-plant prototype. Diligent effort, research, and continued experiment have been required to accomplish the transition.

Among the outstanding examples of locomotive accessories which have followed stationary plant ideas are the superheater, the brick arch, the feedwater heater, the centrifugal boiler feed pump, the stoker, the mechanical lubricator, and restricted maximum cut-off. In all of these instances it was necessary to completely alter the original design in order to adapt them to the locomotive.

In the locomotive we find numerous appliances which have no counterpart in central station practice, but which have been found necessary for economical operation. Among such devices, the introduction of which on the railway was entirely due to research, may be mentioned safety drawbars, radial buffers, automatic wedges, front-end throttles, four-wheel trailer trucks, tandem rod drive, boosters, and auxiliary locomotives, train control and cab signals, automatic bell ringers and whistle blowers, power reverse gears, syphons, superdraft, cut-off control indicators, back pressure indicators, drifting valves, and other kindred accessories.

If we were to attempt to group the various accessories under the headings of economy, capacity and safety devices it would be impossible in many cases accurately to make such a grouping for the reason that a device that was originally intended as a safety device might well have developed into a device producing increased economy or capacity, or vice versa. In addition to the economy resulting from fuel saving many of these accessories make possible greatly reduced maintenance costs. The syphon, which was originally conceived as a capacity increaser and a fuel saver, is also a safety device. Other accessories in this same category are the automatic fire door and power reverse gear. The locomotive booster was originally conceived as being a capacity increaser for the locomotive. Its original conception was for starting the train. Today, under existing operating conditions it has become an important economy device.

The Functions of the Railroad and the Manufacturer

Critics may ask why the railroads themselves do not create, experiment with and develop all accessories for locomotives. The answer is obvious. The railroad's principal object is to sell transportation. It has no interest in commercial activities relative to the development of the locomotive and its parts. Speaking generally, the railroads are in a better position to profit from the research and knowledge of the equipment companies where progress is often keenly stimulated by competition and where some of the best engineers of the country are engaged to conduct research and development.

The history of the research connected with the development of locomotive accessories indicates two fundamentals. First, many of the improvements have had their birth, not on the railroad, but among men who have a wide knowledge of railway requirements and who recognize the possibilities from such improvements. Second, those ideas that have had birth on the railroad are generally acquired by an industry that is in a better position to develop them than the railways themselves. Independent effort on the part of the railroads would involve needless duplication and unnecessary expense. Of course, with problems such as were involved in the draft gear and air-brake equipment the American Railway Association, representing all the railroads, has sponsored the research work that has been necessary.

An illuminating example of the co-operation between the railroads and the equipment industries is to be had in the story of the development of the locomotive booster. This device is used as an illustration as the inventor has received distinguished honors for his contribution by no less a scientific body than the Franklin Institute of the State of Pennsylvania for the promotion of the mechanic arts.

A Typical Case

The original conception of the invention was to utilize some of the unused dead weight of the locomotive to provide additional drawbar pull. This device was of such a character that it could only be developed by the co-operation of the railroads since service tests were the only thing that could demonstrate its success or failure. The early applications demonstrated the soundness of the principle. Development up to this point was of great importance, but considerable further de-

velopment was necessary to bring the booster to its present stage of efficiency.

The history of other accessories is very similar. The policy is the same as pursued by other great industries, such as the power industry, or, for that matter, the manufacturing industry. Tools with which these industries carry on their business are seldom conceived, developed, manufactured and marketed by the industry. Here, as on the railroads, the success of a new device or accessory is dependent upon the co-operation between the user and the manufacturer in the various stages of development.

Anti-Friction Bearings in Railway Service

By J. R. Jackson,
Engineer of Tests, Missouri Pacific

Roller bearings have now been used successfully for more than 12 years on the journals of railway equipment. From 1921 to 1925-6, the experimental work of testing bearings for reliability and the determination of service life was carried out quietly and with little publicity. Most of the applications in service during this period were on passenger cars. In 1926 several of our large systems put into effect equipment programs which called for substantial numbers of passenger-train cars to be built on anti-friction bearings. These cars were of all types which operate in passenger trains and represented a step in the modernization of rolling stock.

The economies which are to be expected from anti-friction bearings were reasonably well established over the 12 years in which equipment has been in service. Some of the bearings have operated more than one million one hundred thousand miles. The reliability in service, reduced starting resistance and freedom from attention for lubrication or other forms of maintenance are well known. Very little new equipment for passenger trains has been built during the last several years and, hence, the further use of anti-friction bearings for this purpose has been somewhat curtailed. They have been used on a majority of the special equipment such as motor rail cars, trailers, etc., which have been built, and unquestionably they will find a very extended use in the light-weight high-speed type of car which is now attracting considerable attention from railway mechanical men.

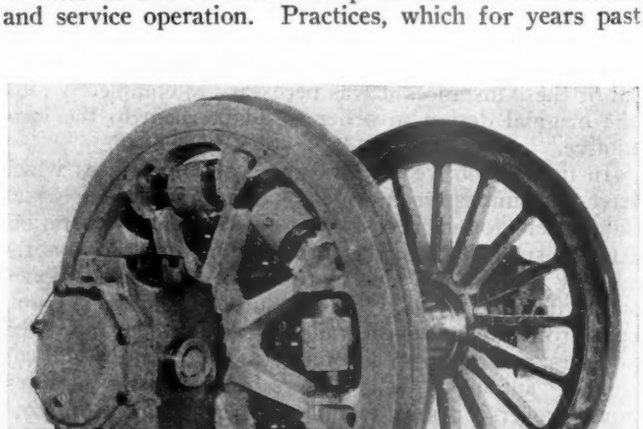
Roller Bearings on Locomotives

The latest and most important developments in the anti-friction journal bearing field have been on locomotives. For a number of years anti-friction bearing journals have been in service on supplementary power, such as auxiliary locomotives and locomotive boosters. However, most of the locomotive development may be dated from 1927 when the first anti-friction-bearing equipped engine trucks were placed in high-speed passenger service. Their extended use at what was formerly a very troublesome point on a locomotive is in keeping with the necessity of making the modern engine a better machine mechanically and of helping it to meet the present-day requirements of high-speed, long locomotive runs and a high factor of availability for power.

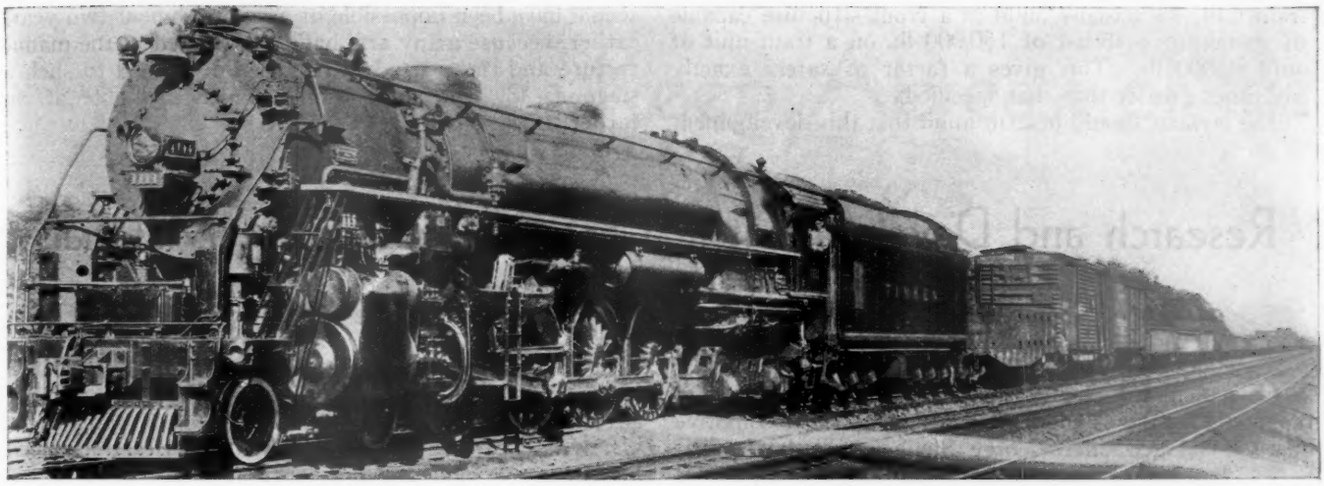
As a result of the engine-truck-bearing performance, the extension of the use of anti-friction bearings to tender and trailer-truck journals naturally followed. In 1930 the first applications to driving journals were made. During the summer of that year one experimental locomotive of the 4-8-4 type, having roller bearings on all journals, was built and placed in service. During the same period the main driving axle of a Consolidation type locomotive on the Delaware & Hudson was similarly equipped. These driving-box applications have shown a performance which warranted others being made, and since 1930 anti-friction-bearing driving journals have been applied to locomotives on the New York Central, the Delaware & Hudson, the Pennsylvania and the Delaware, Lackawanna & Western. Some of these engines have operated for more than 200,000 miles with satisfactory bearing performance and without the necessity of replacement of any parts. Freedom from box pound, the elimination of the wedge, reliability and infrequency of lubrication have all helped to make these applications attractive and valuable to the operating and maintenance man.

In the field of heavy electric traction, anti-friction bearings have also found an extensive use within the last four or five years. With geared drive the application of these bearings to electric locomotive journals does not present a particularly difficult problem in the light of the developments which have already been carried out. The use of these bearings enables the designer to save some badly needed space. Twin motors, developing a rated horsepower of 1,250 per driving axle and operating at maximum speeds of 1,250 r.p.m., are now being used in fast passenger service. On some of the lighter equipment speeds as high as 2,100 r.p.m. are being used. Back of this substantial achievement is a history of world-wide scientific study and research over a period of approximately 35 years.

Indirectly, the results obtained through the application of anti-friction bearings to railway equipment have stimulated research in the whole field of locomotive and car-journal performance, particularly in the study of lubrication and its relationship to frictional resistance and service operation. Practices, which for years past



Roller-Bearing-Equipped Axle for High-Speed, Heavy-Duty Electric Passenger Locomotive



The First Locomotive with a Complete Installation of Roller Bearings on All Axles

have been considered as standards, are being critically analyzed and information is being developed covering modifications in the details of the design of the bearing and the journal box and the kind and method of lubrication which hold promise of considerably improving the operation and service life of friction bearings. These, because of their relatively low first cost and generally reliable service performance, will continue to be used on some classes of railway equipment for some years to come.

Railroad Equipment of High Tensile Steel

By Edward G. Budd,
President, Edward G. Budd Manufacturing Company

Some years ago an alloy of iron-chromium-nickel was produced by the Krupp Company and widely introduced as being stainless, first in cutlery and then for ornamental purposes. It is possible that our company was the first to recognize the great value of this material for structural purposes. It has a normal strength, when annealed, of approximately 100,000 lb., and when cold worked by rolling into sheets or strips reaches an ultimate strength of 150,000 to 250,000 lb. per sq. in. When rolled up to 150,000 lb., it retains a ductility equal to or superior to mild steel. It can be drawn or formed in acute shapes and, after forming, requires no heat treating. This makes possible its fabrication into some shapes which give a very complete utilization of the strength of the metal.

We first used this material in the manufacture of airplane parts, and our company has licensed the leading airplane builders of France and Italy.

It became necessary to develop a method of uniting these sections other than by riveting and, since conventional welding procedures destroy the stainless and other characteristics of the material, there has been developed within our company a process known as "Shotweld"-ing. By this process high tensile steel may be welded together with an efficiency and degree of reliability never attained or attempted by riveted construction.

The possibilities of the use of this material were explained to some of our friends who are the heads of railway organizations, and we found them again quick to recognize the value and with the courage to purchase the product in the face of bad business conditions. We have running now three cars built of this metal. Two more are about completed and we have in process some larger and more powerfully equipped units.

The use of a superior metal calls for an advance in design technique if any economy of cost or weight is to be realized. Many of our engineers are aircraft trained and one benefit of that school is an appreciation of the structural importance of each member. To them a roof becomes no longer a thing to keep the weather out, but a potential beam; the floor combines several useful purposes aside from being a necessary convenience. Strangely enough, when these members are figured to perform certain structural functions, they become much lighter than in conventional practice.

Light weight is not to be attained by attention to structure alone. The urge to reduce poundage must be carried into every appointment and fixture. It is surprising what can be accomplished when that urge is sufficient. More comfortable seats are to be had at 54 lb. than have obtained with the customary ones at three times that weight.

As a matter of comparison, we have completed one coach capable of seating 76 passengers, with two toilet rooms, observation end, having a total weight empty of 24,000 lb., including the trucks with the rubber-tired wheels. A coach made for this service of metals heretofore available will weigh 120,000 lb. The strength of our coach is such as to give protection to the passenger fully equal to that of the standard coach.

This question of safety bears a very definite relation of weight to strength. Weight defeats its own purpose by increasing the force of the blow it is supposed to resist. When we, therefore, are able to reduce weight without sacrifice of strength, and added safety factor results. Not only have our cars been very materially reduced in weight, but the strength proportioned to that weight also has been greatly increased over conventional practice. For instance, where the postal authorities require a front-end stressing of 50,000 lb. for a 125,000-lb.

train unit, we actually build in a front structure capable of sustaining a thrust of 150,000 lb. on a train unit of only 80,000 lb. This gives a factor of safety exactly five times greater than that specified.

The layman should bear in mind that this development would have been impossible of accomplishment two years earlier, because many arts have contributed to the manufacture and these arts had not been developed to such a stage as to make the accomplishment possible at an earlier time.

Research and Development in Car and Locomotive Materials

By Lawford H. Fry,
Railway Engineer, Edgewater Steel Company

Some of our mechanical brethren who have not specialized in railroad engineering point in reproach to the fact that the fundamental design of the locomotive has not changed since George Stephenson's day. That is true, but faith in that fundamental design is supported by the results of a large body of research. Much of this research is represented by road tests. A great deal of it comes from the important tests made by the Pennsylvania on its locomotive testing plant. All of it shows that George Stephenson's arrangement of a fire-tube boiler with cylinders exhausting up the stack provides a combination of steam producer and prime mover which is marvelously well adapted to railroad service.

The difficulties of the designer's task may be shown by the following statement. A modern locomotive must have a boiler which will furnish approximately 70,000 lb. of steam per hour. The engine using this steam must develop about 4,000 hp. Boiler and engine must be carried on a vehicle capable of traveling at 80 m.p.h. The total weight will be about 200 tons and if the locomotive is carried on 16 wheels, as is likely to be the case, the total area of contact between wheel and rail will be only about 7 sq. in.

The first essential of any material to be used in locomotive construction is that it shall be reliable. With reliability assured, strength is required so that the dead weight may be reduced to a minimum. Finally, a material which is otherwise satisfactory must be available at a cost which makes its use economically justifiable.

Boiler Steels

The standard boiler steel 30 years ago was a mild steel with a tensile strength of 55,000 to 65,000 lb. per sq. in. With the rise in steam pressures and increase in size it is natural to look for a stronger material, but such material must not require a radical change in fabrication methods. A step forward was made by the Canadian Pacific in 1926 when a higher tensile steel was tried. This was a 2 to 3 per cent nickel steel with a tensile strength of about 78,000 lb. per sq. in. and sufficient ductility to permit of the usual forming operations. A year or two later the Canadian National put into service some locomotive boilers of carbon silicon steel of approximately the same strength.

Both of these steels result from a large amount of research work done by the steel manufacturers and, in the case of the nickel steel, by the International Nickel Company. The production of steels of this character is not merely a matter of dropping a shot of alloy into a melt of low-carbon steel. Careful study of ingot practice and rolling-mill operations is involved.

Steel-Casting Alloys

Some five hundred locomotives are now equipped with nickel steel and about one hundred fifty with the silicon-steel boilers. Very satisfactory results are reported. It seems inevitable that the use of high-tensile boiler steel will increase. In fact, rumors from the research laboratories predict a new steel, marking a still further advance in this direction.

Twenty years ago the majority of steel castings used in locomotive and car construction were of annealed carbon steel, with an average tensile strength of about 72,000 lb. per sq. in., and moderate ductility. If only the larger castings, such as driving-wheel centers and frames, are considered, it will be found that at the present time at least four improved types of casting steel are being used. Quenched and tempered carbon steel with about 0.45 per cent carbon gives a tensile strength of about 90,000 lb. per sq. in. The so-called Hylastic steel brought out by the American Steel Foundries some years ago gives, when normalized and tempered, a tensile strength of about 100,000 lb. per sq. in. This steel has about 0.35 per cent carbon and owes its strength to its manganese content of about 1.5 per cent. Two alloy steels which have met with considerable success in large castings are a carbon-vanadium and a carbon-nickel. With a double anneal or with a normalizing and tempering treatment the carbon-vanadium steel will have about 87,000 lb. per sq. in. tensile strength and the carbon-nickel about 80,000 lb. per sq. in. The yield strength will be about 49,000 lb. per sq. in. for both and both develop high ductility which is considered particularly essential for locomotive frames.

The successful introduction of these cast steels into railroad service represents much pioneering research on the part of the manufacturers of steel castings, together with co-operative study on the part of the railroad engineers.

Forgings and Bearing Metals

Twenty years ago the Pennsylvania pioneered in the use of quenched and tempered carbon-steel forgings. Common practice at that time was to use annealed carbon steel. Satisfactory practice for the production of quenched and tempered axles and crank pins were developed and are still standard on the Pennsylvania. Heat treatment also has enabled this railroad to develop exceptionally light parts for the valve motion.

Other railroads experimented with alloy steels quenched and tempered to produce a high tensile strength, but forgings of this type have not found wide acceptance in railroad service. In the case of crank pins or axles these steels are handicapped by the fact that mechanical injury of the bearing surface by scoring or overheating brings about a sharp reduction in the total strength of the part. Designers have hesitated to take advantage of the higher tensile strength to reduce the section of the forgings.

Much progress has been made by the introduction of steels which can be used in the normalized and tempered condition. Improvement in the methods of

(*Continued on page 54*)

Fixed Properties Keep Abreast of the March of Progress

Railway tracks, bridges, buildings, terminals and water supply are being constantly rebuilt as experience and research show the way for improvements

EXCEPT for the fact that track still consists of rails and cross ties, there is little about the roadway, structures and other fixed properties of the railways today that presents more than a bare resemblance to their counterparts of the early decades of the railway era. These essential elements of the railway property have been subjected to constant change, in part as an important phase of the program for the movement of traffic in larger units at higher speeds, but largely because of the urge to effect economies. It is a characteristic of the officers of roadway and structures that they have been critical of existing standards of construction. They have been constantly on the alert to introduce improvements. Whether these have been the results of trial and error, inventive genius or true research was not their concern—they were after results and got them. Because of the ramifications of these improvements, which have affected every conceivable phase of construction and maintenance of way, the subject is one of broad scope. For this reason it has been thought best to review it under six separate headings in the following pages:

Modern Track a Product of Research

It is a far cry from the cast iron plates of Colebrook Dale or from the iron straps spiked on wooden stringers to the 152-lb. T-rail now in use on the Pennsylvania, but between them lies more than a century of persistent and untiring research on the part of individuals, the railways and manufacturers. As great a span in both time and efficiency separates the original designs and materials for rail fastenings and those in common use today, while no less effort and research are represented in their development. Similar contrasts are observed when we compare the stone sleeper of the first railways or the pole tie that was cut along the track with the carefully selected, scientifically seasoned and thoroughly treated crosstie of the present, which is adequately protected against decay and mechanical destruction.

No greater distance of either time or design separates the foregoing elements of the track from their prototypes than is found in the present and original designs for switches, frogs and crossings. For proof of this statement, it is only necessary to compare the tongue switch, first used with cast-iron rail and later with both the strap iron and edge rails, or the later stub switch, with those of modern design. Similar evidence, no less startling, of the advance that has been made in design and materials is provided by a comparison of the original cast iron frog, or the pivoted rail, and crossings of the same material, with modern construction of manganese steel of either solid or insert design, which is capable of withstanding the impact of the heaviest locomotives at high speeds.

First Recorded Research in Transportation

Few would be inclined to connect romance and rail; yet the story of its development contains all of the elements of romance. First, a longitudinal wooden stringer, then a flanged cast-iron plate; the next development, important only as a step in its evolution, was an oval section. The first two forms were used with flat-tired wagon wheels, while the latter required a double-flanged, grooved wheel, similar to a pulley. This was afterwards improved by making the wearing surface of the rail and the tread of the wheel flat.

William Jessop, an English engineer of ability, made the next and probably the most important step ever taken in track construction. In 1789, 15 years before the first locomotive was used in transportation, and 36 years before the first common carrier was built, he made an intensive study of the existing types of track. Taking his cue from the "edge" rail and double-flanged wheels, he abandoned the flat wheels and flanged rails and reversed the arrangement by using flat-topped rails and wheels with flanges cast on the tires. Jessop's decision had the most profound effect on the whole after course of transportation, since by putting the guide on the wheel instead of the rail, he made modern railway development possible.

His rails were cast iron bars of the fishbelly pattern, 3 ft. long, which were supported at the ends by cross sleepers to which they were fastened by means of iron pins or bolts which passed through a projecting base. The ease with which these projections broke off, leaving the rail with no lateral support, led to the introduction of the chair and finally to the bull-head rail which is still so largely used in England.

It fell to the lot of an American engineer to make the next important step in rail development. Robert L. Stevens, chief engineer of the newly-organized Camden & Amboy, now a part of the Pennsylvania, recognizing the imperfections of the strap rail, which was used so largely on early American roads owing to the high price of imported iron and the scarcity of iron workers in this country, set about to design an improved rail. Realizing that because of this scarcity of metal workers, any design that required a chair would be impracticable, he made an intensive study of other possibilities. Taking the Birkinshaw rail, then popular in England, as his starting point, in 1830, he designed a T-rail having a wide base which, with only slight modification, except

as to weight, has since been the standard section on American railways.

The next and most important step after Jessop's studies in the development of rail came with the introduction of the Bessemer process of making steel and the casting of 500 tons of steel rails for the London & Northwestern in England in 1862. Axle loads and train speeds had increased greatly since Stevens designed his rail section. Under these loads even the heaviest sections of iron rail deteriorated rapidly and had put a limit on further development in the size of locomotives and cars and in train speeds. The importance of the introduction of steel into the manufacture of rails lies, therefore, in the fact that it permitted a continuation of the development in the size of locomotives and cars and of train speeds. This, in turn, has enabled the railways to develop economies in transportation and improvements in service without which it is questionable whether they could have survived.

Notable as this advance was, it cured only a few of the many evils connected with the manufacture and use of rail. While axle loads and train speeds continued to increase, the weight of the rail remained practically stationary. The processes of manufacture were crude and much of the rail that was turned out was so badly kinked as to be unfit for use. In addition, the multiplicity of rail sections added to the confusion and chaos of the period, which resulted in part from the rapid expansion of the railways, but in larger measure from the lack of co-ordination of the efforts that were being made to improve conditions.

A Distinct Step Forward

Recognizing the necessity for an intensive study of the whole rail situation and despite a lack of technical training among its membership, the newly-organized Roadmasters' Association of America undertook a thorough investigation of rail sections, and in 1887 brought in a report which included designs of sections from 60 to 100 lb. and an earnest plea for a limited number of standardized sections. Eventually broadened to include the reasons and practicable remedies for the wide variation in the hardness and wearing qualities of the rail that was being furnished by the manufacturers, these studies were continued until 1897, when it became evident that more technical knowledge was needed to extend the investigation and carry it to a conclusion than was available within the association.

In this year it requested the American Society of Civil Engineers, the only society then possessing the requisite scientific ability, to continue the research and carry it to a conclusion. The A.S.C.E. accepted the responsibility, and the research it undertook and completed in its effort to find the most efficient section forms an outstanding chapter in rail development. The sections which it designed were adopted and remained as standard on many of the roads of the country for a long period; in fact, after more than 30 years some of these sections are still in current use.

A Forerunner of Modern Track—Strap Iron Rail on Longitudinal Stringers

While the studies made by the Roadmasters' Association did not in themselves definitely solve any of the problems which were causing so much trouble and anxiety, they hold a place of high importance in the story of railway research, since they were the first co-operative studies ever made of a railway engineering subject and thus pointed the way for the modern trend in co-operative research. Furthermore, they focused attention on the importance of improving rail designs and the necessity for a better knowledge of the metallurgy of rail, as well as the need for better manufacturing practices. Again, the exhaustive methods employed by the A.S.C.E. showed how important the results of co-operative research could be.

American Railway Engineering Association Enters Field

About this time another factor in the conduct of research arose in the railway engineering field which has since exerted a wide and powerful influence. This was the organization, in 1900, of the American Railway Engineering Association which, through the medium of permanent committees, is continually engaged in research covering a wide range of engineering and transportation problems. This work is being done so quietly, yet with a thoroughness and regard for scientific accuracy that have bred a high respect for the findings of the association, that few laymen or engineers outside of the railway field know anything about it and even many railway officers do not realize either its scope or value, although the reports of and conclusions derived from these activities are readily available.

Outstanding among these committees, in both the volume and the value of the work it has done or now has under way, is that of the Committee on Rail, which as its name indicates is interested primarily in studying to improve the manufacture and conditions of use of rail, although its assignments also include studies of rail fastenings. Since this committee was organized, it has pursued its studies aggressively and with due regard for the scientific principles involved. No year has passed that it has not contributed information of value and the list of its accomplishments in this field is too large for inclusion here. A number of things that stand out in bold relief, however, should be mentioned.

By 1904, another cycle in the relation between axle loads and rail had been completed and the need for a stronger and harder rail was met by the introduction of open-hearth steel having a high carbon content, for rail manufacture. By 1911, the amount of open-hearth rail rolled had passed that of Bessemer rail and today the latter is practically negligible. With the introduction of open-hearth rail, however, a new danger arose which, in 1911, was designated as the transverse fissure.

Nothing was known about the transverse fissure at the beginning, except that the rail broke suddenly with no previous warning and that a part of the fractured surface was smooth and of a silver-like luster. From the time of its identification, the number of rails detected with this defect has increased rapidly until at present rails are failing from this cause at the rate of about 7,500 a year. Obviously, it was desirable to find some means whereby transverse fissures could be detected in rails before breakage occurred. Supported by the American Railway Association, the Rail committee of the A.R.E.A. set about to find some means whereby this could be done. Intensive studies were made with no apparent success. In the meantime, a number of inde-

pendent investigators had been endeavoring to perfect equipment for this purpose.

One of the Spectacular Successes of Research

Eventually each of these devices was examined and put under test to determine its suitability for service. Not one was found to be adapted for the purpose for which it was designed. The committee then took what later proved to be a most important step and one which had results as spectacular as any that have grown out of railway research. Still supported by the A.R.A., the committee approached the late Elmer A. Sperry, eminent scientist, with a suggestion that it finance a program of research by him, the objective of which was the perfection of a dependable device for the detection of fissures, which would also be practicable from the standpoint of field service. The results met the expectations of the most sanguine, for the transverse fissure detector has demonstrated in service that it not only finds and records fissures, even in the incipient stages, but it does the same for numerous other defects, some of which are also hidden. Furthermore, it differentiates rather sharply between fissures of large, medium and small size or importance. As a result of this outstanding example of research, transverse fissures have ceased to be the nightmare to maintenance officers that they were formerly.

Settling the question of safety was only one phase of the problem, however, since the economic loss by reason of removing the defective rails from service has run into large sums annually. This will be better appreciated when it is understood that since 1919 a sufficient number of rails to lay more than 200 miles of track have been removed from service because of transverse fissures, and that at present a sufficient number of rails are being removed annually to lay 25 miles of track. Growing out of this entire situation, the railways and the manufacturers have undertaken to finance jointly an unusually ambitious program of research to extend over five years in an effort to determine the cause of transverse fissures and what measures are necessary to avoid them. This investigation, which is already under way, will be carried out in the laboratory as well as under normal service conditions in the field. For this purpose, the railways and the manufacturers have jointly appropriated $250,000 which is being expended at the rate of $50,000 a year. Although the investigation is only beginning, a large amount of collateral information has already been collected, most of which would not have been obtained except for the investigation.

No history of rail development would be complete without mentioning the growth in weight. There is little information as to the weight of the earliest rails. Steven's T-rail was designed to weigh 36 lb. to the yard. This was increased gradually to around 45 or 50 lb. at the time the first steel rails were rolled in this country. Weights increased slowly, and in 1892 when both the New York Central and the Pennsylvania adopted 100-lb. sections, 75 lb. was the common maximum with 60 and even 50-lb. rail in common use. With the change to open-hearth rail, the weight has increased somewhat more rapidly, until at present the Pennsylvania, one of the foremost exponents of heavy rail, is using a 152-lb. section which was adopted after several years' intensive study by a joint committee representing the railway and the manufacturers. This rail was designed to carry axle loads of 100,000 lb. moving at the rate of 100 miles an hour. The investigation undertaken by the Kansas City Southern to determine the economical weight of rail for its traffic conditions is also an outstanding example of research applied to track problems.

Modern Track Includes Heavy Rails, Large Tie Plates, Treated Ties, Anti-Creepers and Deep Ballast

Recent developments in this field include the application of welding to the building up of battered joints and to the repairing of frogs and crossings. This practice has been developed through a number of widely separated sources and has been given the most intensive study to perfect it. Still farther back is a record of long research and experimentation on the part of manufacturers to develop equipment and materials suitable for this type of work. More recently and as a corollary to welding, a new practice is developing—the heat treating of rail ends to retard batter. The Chicago, Milwaukee, St. Paul & Pacific, which was the first to do this, spent more than five years in the field and laboratory in perfecting its methods. Another road, the Pennsylvania, is making an intensive study in an effort to develop an alternate method, while a commercial company has perfected equipment to do this work on a contract basis.

Rail Fastenings

Early forms of rail were held to the supporting timbers by bolts or countersunk pins. No effort was made, however, to connect adjacent rails at their ends. The next development was the rail chair, and this was followed by a combined chair and plate to keep the rails in horizontal as well as vertical alinement. Because of its flange, the T-rail was held in place with "hook spikes" which do not differ essentially from those in use today. This method of fastening necessitated some means of holding the rails in alinement at their ends, and this was accomplished by means of a specially designed joint or cast-iron chair which quickly gave place to the fish plate, which provides the basic principle for practically all of the joints in common use today.

Little improvement in rail joints was possible until the introduction of steel into this field. Then a flange was added to make the angle bar. Early angle bars were but little better than fish plates, but manufacturers and individuals devoted much energy to developing new designs of joint fastenings, few of which were more satisfactory. At the time the Roadmasters' Association undertook to study rail, it also started a similar investigation with respect to rail joints. This subject was also referred to the A.S.C.E. along with rail, and became a part of the program of research that it undertook.

It was found early that it was desirable to use a washer with the bolt through the joint. The first type was a fibre washer, but as it mashed out quickly it was superseded by the iron-clad fibre washer, which was still used within the memory of many maintenance officers still in active service. All of the developments so far recorded were made by the railways, either directly

or indirectly. The next step in joint fastenings was the nut lock, which was almost entirely a manufacturer's development. This development has been continued by the manufacturers until today we have the heat treated, high tension spring washer to keep the bolts tight, or the tie plate immobile with the tie.

Early bolts were of iron, which stretched so under tension that tight joints were impossible. Steel bolts were an improvement, but they also stretched under the tensions that were applied in an effort to keep the joints tight under the heavier and heavier loads they were compelled to support. Through the efforts of manufacturers, bolts of high carbon or alloy steel, heat treated, are now available, which have a high resistance to tension and a minimum elongation under tensile stress. When used in conjunction with spring washers, modern joints can be kept to any desired degree of tightness.

Going back to the angle bar. As long as the bolts could not be kept tight, there was little opportunity for improving the joint bars. Coincident with the increased strength of bolts, however, improvements in the design and material for joint bars were made, partly by the railways and partly by the manufacturers, so that today a maintenance engineer is able to choose between a wide variety of angle bars, symmetrical and unsymmetrical, and patented joints, including the head-free type, all of which are heat treated and oil quenched.

Although tie plates were devised about 1885, in an effort to eliminate destruction of the ties by rail cutting, it was 25 years before they came into widespread use. While the idea originated on the railways, the development of tie plates has been particularly a function of the manufacturer. Although the original conception was that of a flat plate, some of the early and most widely used models were nearly as destructive to the tie as the trouble they were designed to correct. As treated ties began to be used extensively, the tie plate became an economic necessity and further intensive study was applied to the size and design for the purpose of eliminating, so far as possible, all degrees of mechanical destruction. Out of these studies have grown stabilized designs of heavy-shouldered plates of ample bearing area, with flat or slightly corrugated bottoms. The latest development, which is finding increasing favor, is a type that is fastened to the tie independent of the rail fastening, and is held immobile by means of shouldered wood screws and high-tension spring washers.

Latest of all of the devices classed as rail fastenings are anti-creepers. Although the first designs were offered to the railways as a completed product, probably no other device has been given more intensive study to improve and refine the design or more careful experimentation and test in actual service. Scarcely more than a quarter of a century old, this device has been particularly a manufacturer's development from the start.

Modern Crosstie a Product of Science

The earliest detailed description of track construction is found in Jaa's Voyages Metallurgiques, published in 1765. At that time, wooden cross sleepers or ties were laid at about three-foot intervals to hold the longitudinal timbers in alinement. It is known from later descriptions that these ties were what are now known as pole ties. With the wider use of iron rails, the wooden sleeper was replaced by the stone foundation introduced by Benjamin Outram in 1800. Many of the early roads in this country adopted the practice from England and laid their rails on stone sills. This method of construction led to serious derangement of the tracks, however, and it was not long before the roads of this country turned to the wooden crosstie.

In many cases, pole ties for construction were cut from the timber felled in clearing the right of way. As time passed and replacements became necessary, similar ties were obtained almost beside the track. It was not long, however, before the logging which generally followed the construction of a new line, depleted the supply of timber. As a result, we find that as early as 1838 the railways began to study and experiment with wood preservation as a means of prolonging the service life of ties.

These investigations were never abandoned, but study and experimenting were continued in an effort to find an effective and economical treatment. The results were generally unsatisfactory because the development of materials and methods was a slow process which had to pause for field tests to determine whether each step was giving satisfactory results. The first large-scale experiment in wood preservation to be made in this country was undertaken by the Louisville & Nashville when it constructed a creosoting plant at Pascagoula, Miss., in 1875. This was followed shortly by a similar plant on the New Orleans & North Eastern for creosoting the timber that was to go in the trestle it was building across Lake Pontchartrain, and from that time the practice developed somewhat more rapidly but still at a slow rate. Wood preservation, as it is practiced today, is practically a development of the railways, and of the last 25 years, although much of the treating is done in commercial plants. The effective methods in vogue today have resulted largely from the intensive studies of a relatively small group of men who have been able to co-ordinate laboratory studies with practical plant and field practices.

Modern crossties provide an outstanding example of the returns which come from the exhaustive study and research which the railways are applying to all phases of construction and maintenance, since they form one item that can be evaluated in dollars and cents. It has been shown definitely that the present use of treated ties is already saving the railways $200,000 a day and that this will gradually increase to $287,000 when all ties in service are treated and the average service life has been increased to 20 years. As a further benefit, which is by no means confined to the railways, through the line of research which has made these results possible, principles of conservation have been established which are of profit to every wood-consuming industry.

An Outstanding Example of Co-operative Research

From the beginning, it was necessary to divert cars or trains from the main route. The earliest form of switch, known as the tongue switch, continued in use with all intermediate forms of rails until the T-rail was adopted. When the latter was substituted for the strap and edge rails, a change in the design of both switches

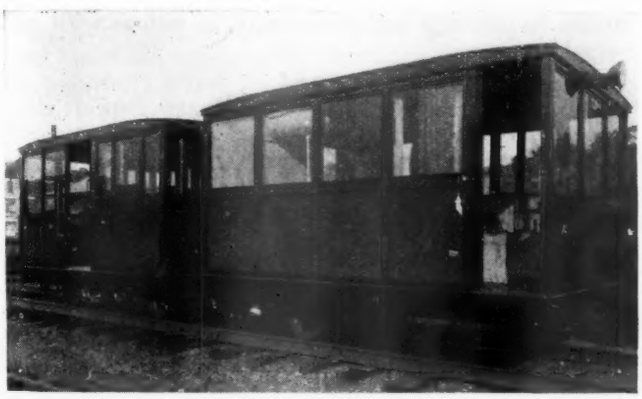
How Pennsylvania Rail Has Grown from 40 lb. to 152 lb. in a Century

and frogs became necessary. The next step was the stub switch, which continued in use as long as the iron rail. With the introduction of steel into rail manufacture, it was succeeded by the split switch, the present form of this device.

Frogs have passed through a larger number of stages. The earliest examples were of cast iron, with deep troughs to guide the flat-tired wagon wheels. With little modification, these were suitable for Jessop's flanged wheels and so were continued in use. With the advent of the T-rail, a pivoted rail about nine feet long was devised as a substitute for the cast frog, but this gave much trouble and most roads reverted to the cast iron frog. As axle loads increased, these frogs became unable to withstand the impact and were succeeded by cast steel. But as loads continued to increase, the latter broke with about the same regularity. This was the situation when steel superseded iron for rail, although the Lewis frog, of which we have no description, seems to have been an improvement over the cast steel and was rather widely used during this period of transition.

Simultaneously with the split switch, the all-rail frog appeared. The business appears to have been attractive, for a large number of manufacturers sprang up. The early forms were extremely crude and inadequate and while competition tended automatically to improve the product, it was long before any principles of design were developed. This was largely because every maintenance officer had his own ideas on construction, so that every one, manufacturer and user alike, was completely at sea as to what should be done. To add to the other difficulties, shop work was inaccurate and generally unsatisfactory. Guard rails and switches suffered similar afflictions.

Recognizing the intolerable situation and the necessity for bringing order out of this confusion, the Road-



Detector Cars Are Now Available to Find Hidden Defects in Rail

masters' Association also undertook studies on this subject, which were continued for more than a dozen years and were not discontinued until they were relinquished to the Track committee of the A. R. E. A. Not a few of the developments of today can be traced to the intensive work that this association did from 40 to 50 years ago.

Some time later, manganese steel became a factor of importance in the construction of frogs and crossings because of its greater resistance to the impact of heavier wheel loads at higher speeds. To work out to their mutual advantage the new problems of shop procedure in the fabrication of this material, the manufacturers organized the Manganese Track Society. In order that each party might have a better understanding of the other's problems and to insure that they will be worked

Modern Turnouts and Double Slip Switches Are a Long Advance From Early Types of Switches

out to mutual advantage, for a number of years the Track Committee and the Manganese Track Society have been working jointly to improve both designs and materials for switches, frogs and crossings.

Only those who are in closest touch with the results of this co-operative research are fully aware of the success that has attended it. But even the layman, if he cares to investigate, will soon be convinced that the results have been substantial and along recognized scientific lines. Such an investigation will bring into sharp relief the present perfection of design and manufacture and contrast it with the crude designs and inaccurate shop work of the days before the railways undertook a program of research or joined with the manufacturers in the present co-operative plan of work.

Heretofore, we have discussed the basic elements of the track, following their development individually. After its organization, the American Railway Engineering Association not only applied the principles of research to these matters more intensively and aggressively than before, but it instituted other investigations of the track as a whole and of the means whereby it can be improved. Prior to 1913, a large amount of such work had been done by individual roads, notably by the Pennsylvania, particularly in its studies of the effective depth of ballast and the test to determine the relative merits of the American and British forms of track construction.

To co-ordinate these scattered efforts and make possible a complete investigation of both the relative and absolute importance of every factor influencing the performance of the track, the association appointed, in 1913, a Special Committee on Stresses in Track under the chairmanship of Dr. A. N. Talbot, which is acting jointly with a similar committee of the American Society of Civil Engineers. For 20 years this committee has constantly been making detailed studies in the field under actual service conditions and evaluating the results. Of such magnitude is the task, however, that the time of completion is as yet indefinite. Without fear of challenge, it can be said that the work of this committee

and the results it has already obtained are outstanding in the field of research. It is also an example of the persistence with which the railways pursue a line of research, once they embark on such a program.

What of the Future

From the foregoing it will be evident that development of the track and its component parts has passed through a number of well-defined cycles. There are indications that we now stand at the beginning of another cycle in this evolution. Evidence is not wanting that, more and more, railway engineers are beginning to think in terms of permanent track construction. An example is the widespread interest aroused by the permanent roadbed of reinforced concrete constructed recently by the Pere Marquette, which is discussed in more detail elsewhere in this issue.

At the beginning of every cycle there has been a marked tendency to break away from settled forms and practices that have become more or less standardized by usage if not by agreement. This departure has never been abrupt, however, but has usually occurred so slowly that it is doubtful if any of those who helped to shape the developments of their day were able to foresee the ultimate result of their studies and experiments. It may be that the beginning of such a transition is to be found in the numerous installations of GEO track that have been made in the last two or three years. While this form of track construction represents a marked departure from accepted practice, it does not present any fundamental changes in design. Although it is of European origin, this does not debar American railways from sharing in any benefits that may accrue from its use. American engineers are, therefore, entitled to credit for having accepted the opportunity to try it out and determine not only its intrinsic merits but also whether it points the way to new developments in track design.

In this review we have merely touched on the outstanding developments which have changed the trends that were being followed previously, and have shown that none of them came by chance but through intensive study by individuals and groups and the ability to build on the experience of their predecessors. To get a complete picture of the advance that has been made in the design and materials for track construction, one must go back to the beginning and follow each development step by step from genesis to completion and then start on another cycle. To do this is not possible in the limits of a single article. If it were done, however, two things would be observed. First, that none of the so-called epochal events happened by chance or came about independent of previous development. Second, that many modifications occurred during the period of transition from the older types to those that replaced them. In other words, with few exceptions, the transition has been gradual rather than abrupt, as might be understood from the foregoing recital.

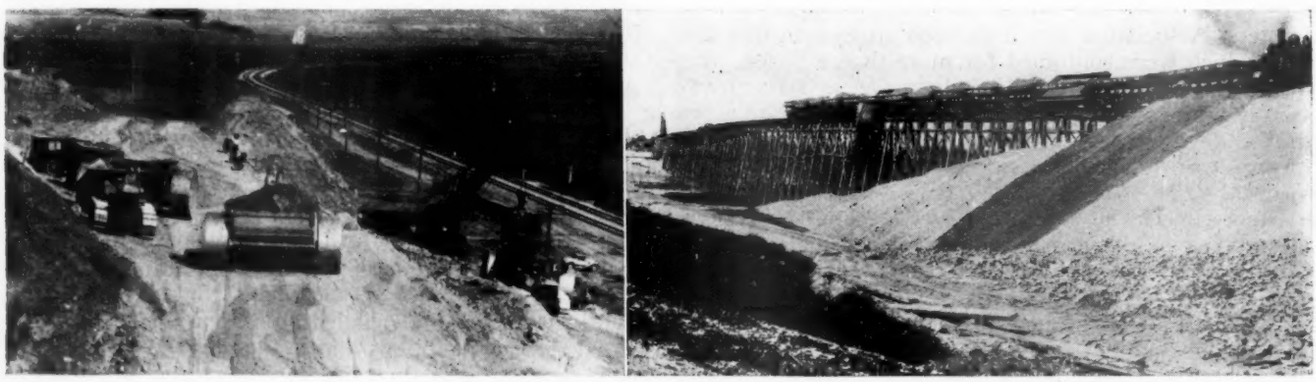
Moreover, it will also be found that back of each forward step is a long history of intensive study and experiment, of trial and failure, often of parallel but independent effort on the part of several individuals, of ingenious design and modification, of long and often disappointing experimentation and of tedious tests in laboratory and field. Since the American Railway Engineering Association entered the field, railway research has more and more been put on an organized basis and much of the work that has been done has been directed toward specific ends which have been selected in advance. That these activities have not been without value is indicated by the fact that American railway engineering standards are accepted by the railways of many foreign countries.

Probably in no other field of research is it so difficult to reproduce service conditions in the laboratory or devise accelerated tests. For these reasons, investigations of track materials have been slow and often disheartening. It is a great credit, therefore, to railway engineers and manufacturers alike that they have carried on their studies so patiently and persistently, as well as with such notable success.

Research and Study Have Made the Roadway

To the layman, the railway roadway (that portion of the right-of-way below and beyond the bed of ballast carrying the track ties) is little more than a series of embankments and gaps through hills or ridges, but to the railway man, the roadway involves many factors of paramount importance to safe and economical railway operation, factors which have long been the subject of special study, investigation and research. The railway roadway, specifically, is the foundation of the railway track, but in its broader sense it is the foundation of all railway service. Without a roadway, suitably designed, constructed and drained, and constantly kept in condition, there would be no such thing as present modern train service, in spite of all of the advances made in track, motive power and rolling stock construction.

Since the beginning of the railways, railway men and



Without Continuing Progress in the Development and Application of Improved Grading Equipment Progress in Railway Betterment Would Have Ceased. Left—Tractor-Drawn Dump Carts. Right—All Steel Large Capacity Dump Cars

those who make the materials and equipment used by them have acted individually and in co-operation with each other to advance and perfect roadway standards and practices. Outstanding associations, including the American Railway Engineering Association, the American Society of Civil Engineers and the American Society for Testing Materials, have given large attention to railroad roadway matters. In fact, the A. R. E. A., since its organization in 1900, has maintained a Committee on Roadway, which deals solely with roadway problems, and the work of this committee has been supplemented constantly by that of other committees studying affiliated subjects.

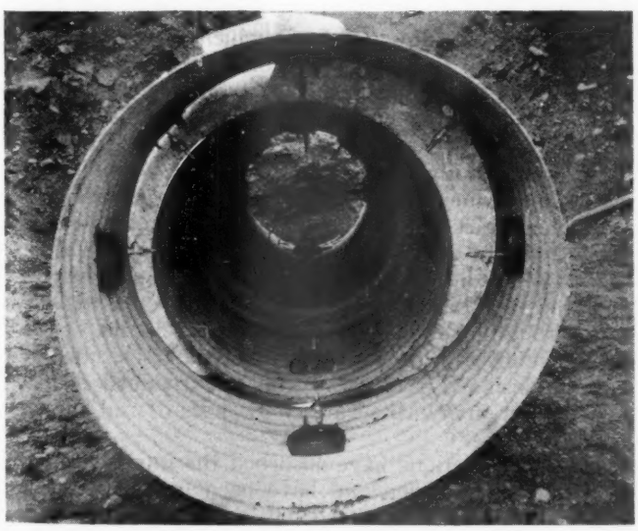
In addition, there is the Roadmasters' and Maintenance of Way Association of America, organized as far back as 1883, whose considerations have been continuously and solely those dealing with roadway and track maintenance. Supplementing these two major associations, there are a number of local clubs of railway maintenance men throughout the country which are constantly studying roadway and track maintenance problems.

Stable Roadbeds Acquired, Not Natural

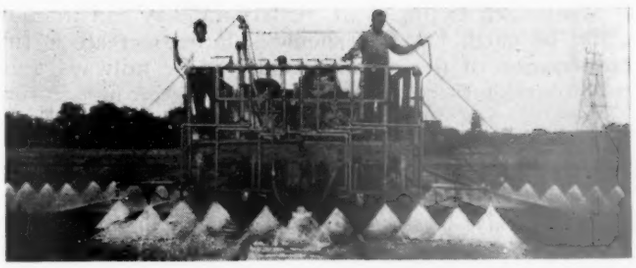
Stability of the roadbed under the pounding action of heavy traffic at high speeds is of paramount importance to safe and economical railway operation. In most cases this is acquired, and not found naturally. Narrow and loosely compacted embankments of the early days, usually constructed of the nearest available material, have given way to wide embankments of carefully selected materials, thousands of miles of embankments having been widened in order to provide the high degree of roadway stability required under the constantly increasing train weights and speeds.

Every factor entering into roadway embankment construction has been studied thoroughly by railway men. Year after year the Committee on Roadway of the A. R. E. A. has investigated and reported on proper filling materials, embankment shrinkage and deformation, unit pressures allowable on roadbeds of different materials, proper widths of roadbed under varying conditions, etc., and, as needed, special instruments have been devised to aid in carrying out these studies in a scientific manner, all in the interest of safer, smoother and more economical railway operation, with a minimum of maintenance costs.

This same situation is true with regard to roadway



Current Knowledge of the Behavior of Culvert Pipes in Fills Was Obtained Through Research—Goldbeck Cells Applied to Corrugated Iron Pipes for the Determination of Earth Pressures



The Economies Now Realized in the Eradication of Weeds Are the Result of Extended Research and Service Tests

cuts. The width of cuts, the angle of slopes, the shape and depth of side ditches, etc., have all been the subject of study and test. Means to prevent slides and washouts through the use of berms, ditches, pipe drains, sodding, special filling materials and special vegetation have been studied for years in hundreds of installations by railway engineering and maintenance men, and even slide protection fences, controlling the automatic train-operating signals, have been installed on miles of roadway to increase the safety of train operation and to preclude the heavy expense of numerous "slide" or "cut" watchmen.

As far back as 1905, the "Manual of Recommended Practices for Railway Engineering and Maintenance of Way," published by the American Railway Engineering and Maintenance of Way Association, now the A. R. E. A., included definite recommendations and principles of procedure covering many phases of roadway construction. These showed not alone early concerted action on the part of railway men in attacking their roadway problems, but also, reviewed in the light of subsequent railway development, that there prevailed, even at that time, marked foresight and understanding of future requirements.

Extensive Development in Construction Equipment

The magnitude of new railway construction under even moderately favorable conditions must be apparent to everyone, but how many appreciate the changes which have been made in the methods employed since the early days of the railways when man-power, aided only by pick, shovel and wheelbarrow forged slowly ahead? How many appreciate further that if these methods had continued to prevail, the railway mileage in this country today would be only a small fraction of what it is, and that the development of the country itself, in almost every respect would have lagged with railway development?

For the progress made, the railways and the country as a whole owe much to railway construction equipment builders, who gave the railways the steam shovel, the power-operated ditcher, the spreader, the locomotive crane, the dump car and many other units of heavy grading equipment, and who early brought this equipment to a high degree of effectiveness. Thus, shortly after the Pittsburgh and West Virginia awarded the contract for the first 17½ miles of a 38-mile single-track extension of its line through some of the roughest country in Pennsylvania between Snowden and Connellsville, 40 steam shovels, a large fleet of tractor-wagons, tractors, side dump cars of various capacities, and at least 200 motor trucks were at work, handling from 250,000 to 500,000 cu. yd. of excavation a month. This one section, which required the moving of 3,100,000 cu. yd. of grading, 60 to 65 per cent rock, with cuts from 85 to 100 ft. in depth and many fills as high as 80 and 90 ft., was completed and ready for operation in less than 18 months.

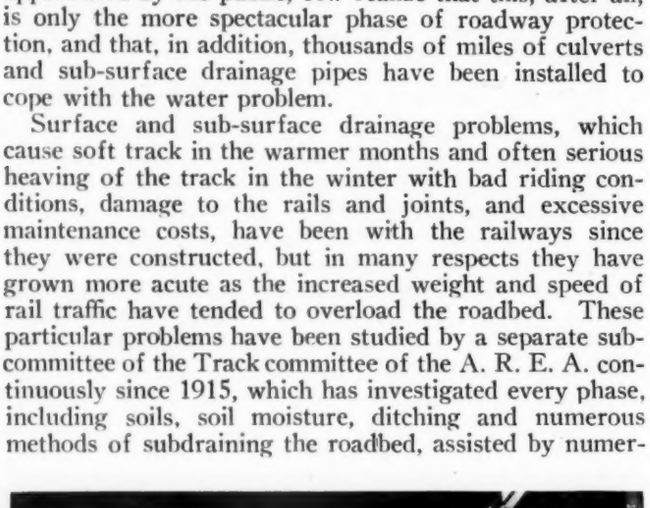
Many such examples of modern railway construction could be cited, but this should suffice to create a full appreciation of the advance made by the railways, railway contractors and railway equipment manufacturers in methods and means of railroad roadway construction. It is useless even to conjecture as to the amount of manpower, time and money that would have been required to have carried out the P. & W. Va. work under old-time methods, because, in all probability, under such conditions the work would never have been undertaken, or if it had, it would have been so modified in its scope and as regards grades, curvature and carrying capacity, that it would be fit only for middle-nineteenth century train operation: and the same could with equal truth be said with regard to much of the high class main-line mileage of the country today.

Problem of Drainage Fought Continuously

Few, other than railway men, realize the hazard and damaging effect of water on or in the roadbed and the extended efforts that have been put forth by the railways in coping with this problem. Fighting floods is a problem of all roads to at least some extent, and in this, millions of yards of riprap and hundreds of miles of other forms of bank revetments and flow retards have been placed. In many cases river channels have been changed and dams, levees, dikes, bulkheads and jetties have been constructed, often far from the railway property, to afford it suitable protection. What methods to use and how best to apply them in the multiplicity of varying conditions arising have long occupied the attention of railway men, both singly and in association with each other.

While some of the major efforts of the railways in flood protection work may occasionally be observed and appreciated by the public, few realize that this, after all, is only the more spectacular phase of roadway protection, and that, in addition, thousands of miles of culverts and sub-surface drainage pipes have been installed to cope with the water problem.

Surface and sub-surface drainage problems, which cause soft track in the warmer months and often serious heaving of the track in the winter with bad riding conditions, damage to the rails and joints, and excessive maintenance costs, have been with the railways since they were constructed, but in many respects they have grown more acute as the increased weight and speed of rail traffic have tended to overload the roadbed. These particular problems have been studied by a separate subcommittee of the Track committee of the A. R. E. A. continuously since 1915, which has investigated every phase, including soils, soil moisture, ditching and numerous methods of subdraining the roadbed, assisted by numerous individual railways and by the manufacturers of culvert pipe and pipe materials.



The Growth in the Volume and Weight of Highway Traffic Has Resulted in a Drastic Change in Highway Crossing Construction—An Example of a Modern Metal Crossing Pavement

Both in the field and in laboratories, pipe and pipe materials have been studied and investigated, not alone from the standpoint of strength to withstand the loads of railway equipment, but also from the standpoint of durability in resisting the ravages of the elements. In this latter regard, metallurgists, chemists and industrial and institutional experts and laboratories over the country have contributed. Outstanding among these efforts have been those of the culvert manufacturers' associations, one of which, for a period of years, in co-operation with railway men, conducted scientific laboratory and field tests with the view of improving the quality of their product and more closely adapting it to the requirements of railway service.

Scientific laboratory investigations and tests of corrugated culvert and drainage pipe were begun about 1916. Recognizing the limitations of such tests, however, in spite of carefully designed testing equipment, built specifically for the purpose, field tests were soon organized at various points and suitable measuring instruments were developed to record pressures on installed pipe with a high degree of refinement. In 1925, extensive field tests of corrugated pipes of different diameters were initiated on a new line under construction by the Illinois Central near Farina, Ill., and, surrounded by the highest development of scientific skill, were studied over a period of several years, with conclusions which not only completely altered existing opinion with regard to corrugated metal culvert pipe, but which also demonstrated beyond doubt its general adaptability for railroad use in large diameters and under high fills. That this is true is evidenced by the fact that, while as late as 1923 the Committee on Track of the A. R. E. A., still held to the belief that corrugated metal pipe gave best results when placed not less than 3 ft. nor more than 10 ft. below subgrade, such pipe is now used commonly, and with satisfactory results, in fills up to 80 ft. or more in height.

Permanent Roadbed Not Overlooked

Confronted with swamps, bogs, wet cuts and other natural foundation of insufficient bearing power, much study and experiment has been given to special types of roadway construction to meet these conditions. That these efforts have been effective is evidenced by the fact that hundreds of miles of such unstable territory is today traversed by the railways with not the slightest change in operating or riding condition which would bring it to the attention of the traveling public.

There are many physical and economic reasons why a "so-called" permanent type of roadbed construction is not attempted generally by the railways, but, in spite of these, much study has been given to the possibilities of greater permanence of construction. Records show that permanent track construction was considered as early as 1899, and that in subsequent years numerous designs of roadway have been suggested and installed, ranging from those having thick sub-bases of carefully placed boulders, through many combinations of steel and concrete construction, with or without timber tie blocks, to scientifically designed reinforced concrete roadbed slabs of various sections, with a variety of types of rail supports and fastenings.

These installations have absorbed the interest of hundreds of railway men and have been made the subject of numerous studies and technical reports. Possibly the most outstanding of the more recent installations have been two on the Pere Marquette, made in co-operation with the Portland Cement Association, to develop the possibilities of a reinforced concrete slab roadbed for

general use. One of these installations, ¼ mile long, was made in 1926, while the other, a 400-ft. extension of the first installation, but incorporating many changes in design, was made in 1929. Both of these installations were conceived, developed and constructed only after most exhaustive research and study, and were surrounded with the most competent skill to be found on the railways and in the cement industry.

To date, much has been learned from the installations. In some respects, they have demonstrated the necessity for alterations from the original design; in others they have fulfilled expectations. Whether they will afford better track and lower maintenance costs over a sufficient period of time to justify the large added cost of their construction, only time can tell.

Grade Crossings Receive Large Attention

In like manner, study and research have taken place in every other factor of railroading which can be considered under the head of roadway. As far back as 1908, grade separation and track alinement, especially in cities, had been studied intensively on the railroads and, already by that time, prior to the development of the automobile to any extent, hundreds of highway-railroad grade crossings had been eliminated. In fact, as early as 1908, the Committee on Roadway of the A. R. E. A. recommended that grade separation be carried out wherever possible.

In recent years the problem of paving at railroad-highway grade crossings has received much attention from both railway officers and certain manufacturers of crossing materials, and marked progress has been made in this direction. Today, the more permanent types of such paving, including asphalt, bituminous mixtures, concrete and metal, developed after much study, are coming into more general use on all railways, in spite of their considerably higher first cost, as compared with ordinary plank, used to such a large extent in the past, and still in service at thousands of crossings where light vehicle traffic prevails.

As far as strictly railroad operation is concerned, a grade crossing is a grade crossing, largely regardless of the type of pavement provided. Therefore, it is not unreasonable to expect, with the railways paying the full expense of construction and maintenance in most instances, consideration of the more permanent types of paving must include the factors of expense and durability as well as the desire of the motoring public for the best crossing conditions possible. Through developments on the part of manufacturers and the results of numerous service installations made by the railways, these factors of expense and durability are being brought closer and closer in line, which promises more widespread use of the more permanent and desirable types of crossing pavement in the future, especially at points of heavy highway travel.

Many Other Problems Studied

For years railway men and the manufacturers of culvert pipe have studied the economies of eliminating many bridges and trestles through the substitution of fills with culverts through them. As a result, thousands of bridges and trestles have been eliminated on the railways, with large economy and with improved track conditions. Tunnel construction, alteration, maintenance and ventilation have also received widespread study among railway men, railway contractors, and those furnishing equipment or machinery for tunnel construction or maintenance, with the result that costs have been reduced materially, permanence of a high degree has been attained, and safety and comfort have been made equal to that on open track.

The disadvantages of many types of mass masonry retaining walls, employed so commonly since the early days of railway construction, have also received attention, and, as a result, reinforced concrete and preformed metal cribbing, easy and economical of erection, have been developed by companies serving the railways, and have already saved the railways hundrds of thousands of dollars in track elevation and bank retaining work.

An Example of Roadway Research—the Concrete Roadbed Installation on the Pere Marquette at Beech, Mich.

Few realize the problem of weed growth on the railroad roadbed and the further problem of roadway dust which would engulf fast trains at many points if not controlled, but both of these problems have long been the concern of railway and railway supply men. Today, as a result of years of study and practical experience, several methods and numerous units of equipment have been developed for the economical destruction of weeds, which, in many sections of the country, would choke the roadbed, foul the ballast, prevent drainage, and well nigh prevent train operation, if not destroyed. These include principally, equipment for the burning, steaming and mowing of weeds, the discing and harrowing of the ballast to destroy weed growth and to stimulate drainage, and the highly developed method of destroying all forms of plant life by the application of chemicals, even to the extent of utilizing chemicals which are non-poisonous to animals which may get on the railroad properties.

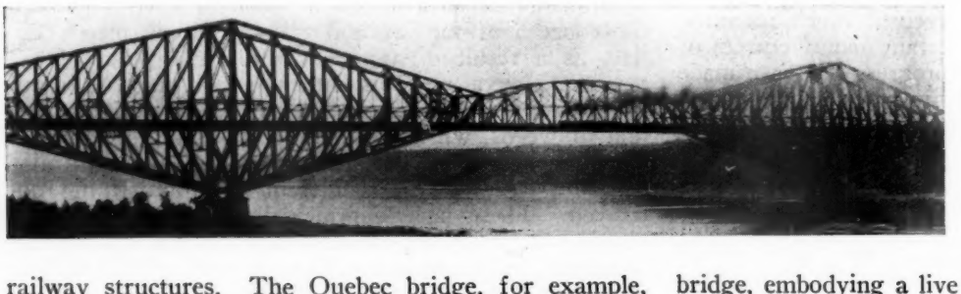
The control of dust is another roadway problem, consideration of which has been just as live on the railways. One of the important considerations which has brought about the use of crushed stone, gravel and slag ballast on thousands of miles of roadway is the fact that these materials minimize the dust nuisance of fast train travel. Where such ballast materials are not justified by the weight and density of traffic, oiling of the roadbed has been resorted to on a large scale by a number of roads, and, with the co-operation of certain of the oil companies and several equipment manufacturers, has been developed to a high degree of efficiency, both as regards character of oil used and method of applying it.

Right-of-way fencing, including both the mesh and posts, may be a small factor in railroad right-of-way expenditures, but even these materials, of many types, have absorbed the time and interest of many railway men, manufacturers and scientific investigators over a period of at least 20 years. As a result, many specifications, carefully built up, now govern strictly the manufacture of these materials, and thereby afford the railways the highest possible quality.

All in all, the railway roadway of today, in its many ramifications, is the result of long investigation, study and research by many specialists in railway and manufacturing service alike, each contributing to the structure over which the nation's traffic moves with such regularity and safety.

Railroads and Bridges—Twin Developments

It is more than a coincidence that the century which witnessed the beginning of railway transportation and the spread of its network of lines over the American continent also saw the genesis and development of modern bridge engineering. The coming of the railways greatly expanded the need for bridges, but more than this, it called for stronger and better structures than those that had sufficed for the modest requirements of stage coach traffic. The stone masonry arch and the pile trestle of antiquity were readily adapted to the requirements of the railways, but rail transportation could not enjoy its full effectiveness unless all streams were bridged, regardless of obstacles which in the case of highway stream crossings gave resort to ferries. Thus, the bridge builder of the day was afforded opportunity for the fullest expression of his art, and the development of truss design, which was then in its infancy, was given an impetus that was soon to bring about a complete revolution in bridge building. It led to the gradual unfolding of the principles of scientific design and afforded the incentive for bold initiative in the expanding of its possibilities through resort to ever-increasing lengths of span. The simple span and cantilever types especially have received their maximum development in railway structures. The Quebec bridge, for example, still stands supreme in its class, while the Hell Gate bridge for several years following its construction comprised the longest span for a steel arch.



The Greatest Cantilever Bridge in America is a Railway Structure—the St. Lawrence River Crossing at Quebec

Movable Bridges

The severe limitations of grades imposed on railways compelled them to assume leadership in another direction, for whereas the builders of highway bridges in many cases were able to meet the requirements for overhead clearance at navigable streams by high bridges with steep approach grades, the railroads were more often compelled to construct low-level crossings with the attendant requirement for a movable span. Even in the period from 1903 to 1923, during which there was a marked decline in new railway construction, the number of movable spans built for railway bridges was nearly double those constructed for highway use, according to the records of the largest fabricator. Therefore, because the railways have built more movable spans, because these average much heavier, and because they include the longest spans of these types, this special field of engineering has been influenced greatly by the requirements of railway structures. Moreover the requirements for the protection of rail traffic over movable bridges have given rise to a technic in the way of interlocked safeguards that have no counterpart outside the railway field.

Dominant Position of the Railway Bridge

However, the railways have exerted their greatest influence on the advance in bridge engineering because for years the larger proportion of all bridges of any consequence were built for railway use. This was owing not only to the fact that the highway did not cease to be more than a local utility for three quarters of a century following the advent of the railroads, but also because the progressive increase in loads called for the replacement of railway bridges after a relatively short service life. The repeated investigations into the need for retiring old bridges afforded exceptional opportunity for the devising of improved practices, with the result that railway bridge engineers became much more exacting in their specification requirements. In fact, the idea of competitive bidding on the basis of detailed specifications originated with Octave Chanute, when he was chief engineer of the Erie in 1874.

The change from empirical or intuitive methods to mathematical stress analysis in proportioning the parts of a truss or plate girder span was a rather slow process, but because railway loads were heavier and more readily determined it was but natural that definite consideration of actual live loads was given more attention in railway bridge work. Rational design was therefore advanced another step in 1875 with the issuance of the specifications for the Cincinnati Southern's Ohio River bridge, embodying a live loading expressed in the form of a wheel-load diagram. But there were still many gaps to be filled before rational methods could be applied to the proportioning of all parts of the bridge spans, and the railway bridge engineers, because of their intensive experience in maintenance as well as in design and construction, exerted a profound influence in the advances made.

With the organization of the American Railway Engineering and Maintenance of Way Association (now the A. R. E. A.), railway engineers came to occupy an increasingly important place in the improvement in bridge engineering practice. Because of the rapid developments in bridge design, the increase in loads and the introduction of structural steel, the last decade of the nineteenth century was one of wide variations in practice and specification requirements, and the Iron and Steel Structures committee of the new association became the chief agency for the correlation of existing information and the unifying of practices.

In general, it may be said that this committee addressed itself to the task evolving specifications, but whether the task at any given time covered specifications for design, or for materials, or for workmanship, the pursuit of the project almost invariably gave rise to research fostered by the association or by individual railways, or to painstaking compilations and interpretations of the results of research conducted by others. These findings were given expression in specifications, which, instead of becoming moribund, have been subjected to almost constant revision and elaboration as the discovery of new facts justified changes. The engineers of

the bridge fabricators as well as consulting bridge engineers have collaborated in this work, thus bringing about a co-operative movement for a uniformity in practice and a standardization of requirements for material and workmanship that have resulted in a marked reduction in costs.

The Benefits Gained

Another result of this work was the general adoption of the "Cooper" system as a common convention for live loads. Turneaure's experiments, financed by contributions from individual railways, pointed the way to a rational study of the impact effect of locomotive counterbalance. Tests of riveted joints, columns, rollers, pins, etc., have all had their effect in more accurate design procedure and therefore more efficient designs.

But this is not all, for the more accurate knowledge of the properties of materials, of the exact nature of the forces imposed on railway bridges and the behavior of structural parts under load has permitted the railway bridge engineer to work within a much closer margin in determining the limiting capacity of old bridges. The result has been a saving of many millions of dollars in avoiding the premature replacement of old bridges.

Co-operation of the railways and the structural steel fabricators has been responsible for many advances in the application of improved materials and practices. A special chrome steel was employed in the famous Eads bridge of the St. Louis Terminal Railroad at St. Louis, while the Chicago & Alton bridge over the Missouri river at Glasgow, Mo., built in 1879, was the first bridge to be made entirely of commercial structural steel. In 1915, studies pointing to the economy of a steel of high strength in the long spans of the Chicago, Burlington & Quincy bridge over the Ohio at Metropolis, Ill., led C. H. Cartlidge, late bridge engineer of that road, to accept the proposal of the American Bridge Company that silicon steel be employed, thus marking the first structural use of that material. Shortly thereafter, collaboration between Mr. Cartlidge and the engineers of the same fabricator gave rise to the first use of heat-treated eye-bars, in the Burlington's Missouri River bridge at Kansas City.

The severe limitations imposed in the erection of railway bridges by the necessity for avoiding interruptions to traffic have been responsible for the exercise of a high order of engineering skill on the part of those represent-

The Ballasted-Deck Creosoted Pile Trestle is Distinctly a Product of Railway Initiative and Research

The Lackawanna's Tunkhannock Viaduct is America's Outstanding Concrete Bridge

ing both the railways and the bridge companies in the many projects that have imposed special problems of this character and the high standard of efficiency of the equipment and personnel developed by the several leading bridge companies has been attained in large part in meeting the exacting requirements of railway work.

Wooden Trestles—a Railway Development

In the early days, the evolution of the wooden truss span and the combination wood and metal bridge passed through the same progressive stages as the all-metal structure, but eventually they were unable to compete with the latter on other than pioneer lines in forested territories. The story of the pile trestle is entirely different, for while the high frame trestle was gradually superseded by the steel viaduct, the pile trestle has passed through a transition that has enabled it to maintain an important economic status.

Comprising the most elemental of load-carrying structures, whose history goes back into antiquity, the pile trestle offered little opportunity for modifications of design of an epoch-making character. Nevertheless, the attention which was centered on its primary shortcoming, namely, its short life, gave rise to a far-reaching development. Pioneer efforts at the application of preservative processes to the timbers and piles used in a number of structures of this class, followed by years of experimentation and the careful recording of service data, established the economic position of the creosoted wooden trestle, and it is not too much to say that but for these efforts to increase the life of timbers in wooden trestles, the art of wood preservation would still be confined almost entirely to the treatment of crossties. It is clear, therefore, that the practice of treating wood on the American continent is distinctly a railway development.

This development was responsible for an improved type of structure, the ballasted deck trestle, while such other modifications have been predicated on the requirements of good results in treatment, of which the most recent advance is the practice of framing the timbers before injection of the preservative.

Influence in Masonry Structures

In so far as it concerned the use of stone and brick masonry, railway bridge building involved but the adaptation of an art that had long been established on a high plane. However, the impetus that was given by railway construction to the bridging of important streams, led to advances in foundation design and construction in

which the builders of railway bridges played a leading part. The Eads bridge was the first structure with large foundations to be placed by the pneumatic process in America. However, it was the advent of concrete construction on a large scale, following the growth of the American manufacture of portland cement and the promulgation of the principles of reinforced concrete design during the nineties, that threw the railways in the forefront in the field of masonry work.

The transition from stone masonry to concrete was rapid, middle-western railways taking the lead in the adaptation of reinforced concrete, first for box culverts and later for slab spans, which found wide application in grade-separation structures and trestles, as well as in ballast decks for plate girder spans. This development was in the formative period just at the time that the A. R. E. A. was launching its diversified activities, and opened a broad field of work for its Committee on Masonry, which played a leading part in bringing about the standardization and improvement of practices in this new field, collaborating freely with such organizations as the American Society for Testing Materials, and a group of manufacturers of cement, who later organized the Portland Cement Association. Railway men also participated actively in the several joint committees on concrete and reinforced concrete, and the engineers of various railways were among the first to apply the improved practices in the making of concrete developed as a result of research work conducted by the Portland Cement Association and others.

Initiate Other Improvements

While mention has been made above of the early adaptation of reinforced concrete to slab span bridges, this is only one of many applications developed to a high degree in connection with railway construction projects. Railway engineers were responsible for a marked advance in abutment design, they were among the first to install the reinforced concrete pipe culvert, while the cellular type of retaining wall as well as the reinforced concrete crib wall had their beginnings in railway drafting rooms. Concrete arch bridges have also had an important place in railway construction, among which the Tunkhannock viaduct of the Delaware, Lackawanna & Western comprises one of the great masterpieces of the American engineer.

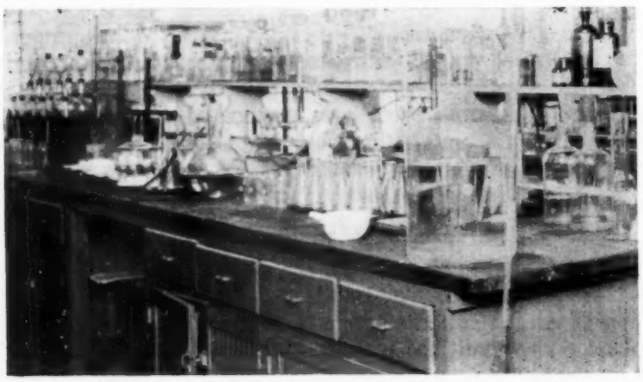
The development of the ballasted floor bridge, particularly in its application to grade-separation structures in cities created a demand for effective waterproofing early in the present century under exacting conditions that had not previously been imposed. This gave rise to the intensive research and experimentation carried out jointly by the manufacturers and the railways, which has borne fruit in the perfection of products and practices that have met the requirements with a high degree of success.

Railway bridge engineering was in a high state of development before the program of wholesale highway construction was given its primary impetus. Except for street and highway bridges of a major character, which were designed and built under the direction of consulting bridge engineers or the engineers of the larger municipalities, highway bridge practice at that time was of a low order. It is not surprising, therefore, that with the inception of highway construction on an organized basis, its engineers turned to the practices of railway bridge engineers for guidance. It is of interest in this connection to note that the standard specifications for steel highway bridges are the work of a joint committee composed of representatives of the A. R. E. A. and the American Association of Highway Officials. Likewise, the excellent service rendered by the creosoted pile trestle has been responsible for the adaptation of this distinctly railway development to highway use.

Modern bridge engineering is the composite result of the gradual unfolding of the laws of mechanics and the development of improved materials of construction, plus a century of practical experience. And because during this same century railway building created the primary demand for bridges, the designers and builders of railway bridges have exerted the dominant influence in shaping the course that has been followed in the perfection of practices in this important branch of engineering.

Railroad Water Problems Yield to Technical Advances

The problems which have confronted the railroads in providing water for locomotives, power plants, trains and other uses, and the way in which these problems have been met in thousands of different situations, furnish one of the most colorful and commanding records of railway progress and accomplishment. It is a record rich with the experiences, mistakes and resourcefulness of railway men and with the telling effects of intensified research by engineers, chemists and manufacturers. Railway operation is becoming vastly more economical and efficient with the technical improvements being made throughout the ramifications of railway water service.



Railway Water Supplies Are Constantly Subjected to Scientific Analysis

Most conspicuous among the developments is the work which has been done in improving water supplies for making steam. Normally, the railroads require approximately 500,000,000,000 gal. of water annually for all services, of which 350,000,000,000 gal. is used for locomotives. This is enough water to supply the largest city; it makes water the leading material in point of weight or volume that is used by railroads. The sources from which this water is obtained are widely scattered and the differences in quality are greater. Most waters are either laden with mud, charged with gas, polluted with mine drainage or vegetable matter or impregnated with minerals capable of causing incrustation, corrosion or foaming under heat and pressure. Locomotives traveling from place to place under varying operating conditions are particularly susceptible to these impurities

and the problem is accentuated with the increasing pollution of streams and the increased size and utilization of steam power. Thirty years ago, the average locomotive was built to pull 1,000 tons or less over a 100-mile division at 15 m. p. h. Today they pull 4,000 tons and more several hundred miles at 50 or more m. p. h. Poor steaming, defective lubrication, train delays, explosions, fuel losses and extra maintenance cost attributed to impurities in water are serious in such operations.

Scientific study has been directed by the railroads to determine, by chemical analysis and experiment, the composition and effect of each type of water on boilers and their appurtenances under varying conditions. Special committees have had the subject under constant study. The libraries and research equipment of universities have been utilized and the laboratories maintained by manufacturers, as well as those maintained by railroads, have added to the knowledge of the subject, with the result that railroads are now in possession of advanced knowledge on handling feedwater.

Better Selection of Water

With this knowledge, the railroads have, in recent years, been particularly exacting when developing new supplies to avoid the mistakes made in the past of passing lightly over the quality of water or disregarding it altogether. The geology of the source and the possibilities for pollution are investigated and thorough chemical examinations are made in laboratories before each project is undertaken and repeatedly following their utilization. Supplies in use are graded on the basis of their quality and wholesale abandonments of existing supplies have been made for the purpose of eliminating objectionable waters. Over 60 water stations have been closed on one road in the past five years. This progress in the better selection of water has been carried to the point of building great reservoirs at considerable expense and even showing industries and municipalities how to improve their own supplies to encourage or permit their use by railroads.

Feedwater Treated

Practically all roads have also undertaken the treatment of water for the purpose of improving its quality. They have studied and extensively used all the chemical preparations devised for feedwater and have been pioneers in the development of roadside facilities designed to remove incrustants from the feedwater before it reached the boiler. In recent years, this work has been stimulated and extended by better technic in handling feedwater. Notable contributions have been made by manufacturers specializing in water treatment, who, with the aid and encouragement of railroads, have developed apparatus and chemicals capable of reducing the cost of treatment and who, by scientific progress in testing of boiler waters and handling locomotives, have improved the results obtainable with boiler chemicals.

Thirty years ago, there were practically no water-treating facilities in railway service. The number of installations now exceeds 2,000. They include approximately 1,200 wayside treating plants of the lime and soda type, ranging in capacity from a softening rate of 50,000 gal. per day to more than 2,000,000 gal. per day, and producing, in the aggregate, about 90,000,000,000 gal. of treated water annually. They include approximately 600 plants equipped with apparatus, by means of which 15,000,000,000 gal. per year is treated with soda ash or sodium aluminate. They include approximately 350 plants at which about 18,000,000,000 gal. of water is treated with commercially-prepared boiler compounds, and they also include approximately 100 wayside plants, at which 12,000,000,000 gal. of water per year is softened and clarified by the zeolite process.

At present, approximately 135,000,000,000 gal. of water per year, or about 40 per cent of all the water consumed annually by locomotives, receives some kind of treatment before reaching the locomotive. Imposing quantities of water also receive treatment after it reaches the locomotive by the use of preparations developed in the scientific laboratories of chemical companies which have made a specialty of railroad problems. On some roads, entire districts are now completely equipped with treating facilities. On one road, 90 per cent of all the objectionable water on the railroad is now receiving treatment. On another road, over 80 per cent of all the water is treated and the worst waters are now confined to supplies which at one time would have been considered excellent for use in the natural state.

Large Fuel Savings

The results vary with the water facilities and the organization of the work, but, as a rule, they have been pronounced. In case after case, costly installations have paid for themselves in the first year. Boiler explosions attributable to bad water are now exceedingly rare, and instances of locomotives having to give up their trains on account of water conditions are almost unheard of. In contrast with 245 engine failures occurring in one month on a certain section of one road because of water conditions, prior to its treatment, and causing train delays of from 1 to 4 hours with blockades and reductions of tonnage, the train failures attributed to water conditions are now less than 5 per month. Locomotive failures charged to leaking flues on another road have been reduced, largely because of improved water, from a total of 787, or 1 failure per 100,000 locomotive-miles, in 1911, to a total of 11 in 1929, or 1 failure per 4,340,000 locomotive-miles. At present, much higher mileages per failure are reported. Again, instead of washing out boilers after 500 or 600 miles, or less, railroads with well-supervised water service now operate their locomotives from 2,000 to 3,000 miles per washout, although engine runs are invariably longer than heretofore. The lives of side sheets and fireboxes in bad-water districts have been doubled. Boiler tubes, which once were removed and scrapped in less than a year, are now running the full government limit of four years before being removed from the boiler and, in many cases, by successive "safe-ending" have had their ultimate life extended to 12 years. One road has secured a year's extension beyond the four-year limit for tube renewals in more than 150 cases since 1929. Another has been allowed 60 extensions already this year.

Tests indicate that scale on flues $\frac{1}{16}$ in. thick will increase the amount of fuel required by at least 10 per cent and scale $\frac{1}{4}$ in. thick will increase it more than 25 per cent, while the American Railway Engineering Association computes the saving in fuel and boiler maintenance from clean boiler water as equivalent to 13 cents per lb. of scale removed or otherwise prevented from attaching itself to the heating surfaces. It is significant of the economies of water treatment, therefore, that over 3,000 tons of incrustants are being removed from the water on some roads every year—enough to make a train load. In most cases, the great advances which have been made in train performance in the last 10 or 15 years would be out of the question without the improvements which have been made in the water supply. With present forces, operations would have been paralyzed during the past three years in many territories with water supplies in the condition they were 20 or 30 years ago.

Notable progress has also been made in modernizing

pumping facilities with a view to adapting them to increased demands for water, adjusting the service to rearrangements in train operation, providing more reliable supplies or reducing the cost of operating and maintaining pumping facilities. Thirty years ago, water was pumped largely by wind mills and steam plants. Service tanks seldom held more than 50,000 gal. of water, and the services of pumpers and repair men were constantly in demand to keep the plants in operation. Then came the gasoline engine. The greatest advance, however, has been made in the last 10 or 15 years with the introduction of the semi-diesel oil engine, the increased accessibility and reliability of electric power and improvements in the centrifugal pump. Hundreds of old water stations throughout the country have been rebuilt to utilize this and other equipment by railroad technicians and developed in the laboratories of manufacturers.

Electrically-operated centrifugal pumps are now used in place of plunger pumps in wells and have even supplanted triplex pumps for operating against heavy pressures. The recent installation of a multiple-stage centrifugal pump in a relatively inaccessible place to raise water 3,000 ft. in one lift is an example of this progress. The small wood roadside tank has given way to steel structures of from 100,000 to 200,000, and, in some cases, 1,000,000-gal. capacity. Electric apparatus, including float and time switches and recording devices, has been utilized so that many remote pumping plants are now stopped and started by push-button controls installed long distances away. Many softening plants are treating over a million gallons of water per day with only part-time attendance because of their developments. On one road, 56 of 63 pumping stations are now electrically operated and 25 are automatic. Another road has installed 58 automatic electric plants since 1923.

Other improvements include the increase in locomotive tender capacities from 3,000 and 5,000 gal. to sizes holding from 12,000 and 25,000 gal., and the construction of large reservoirs, by means of which supplies of suitable water are now assured and the cost of hauling water, in some cases, entirely eliminated.

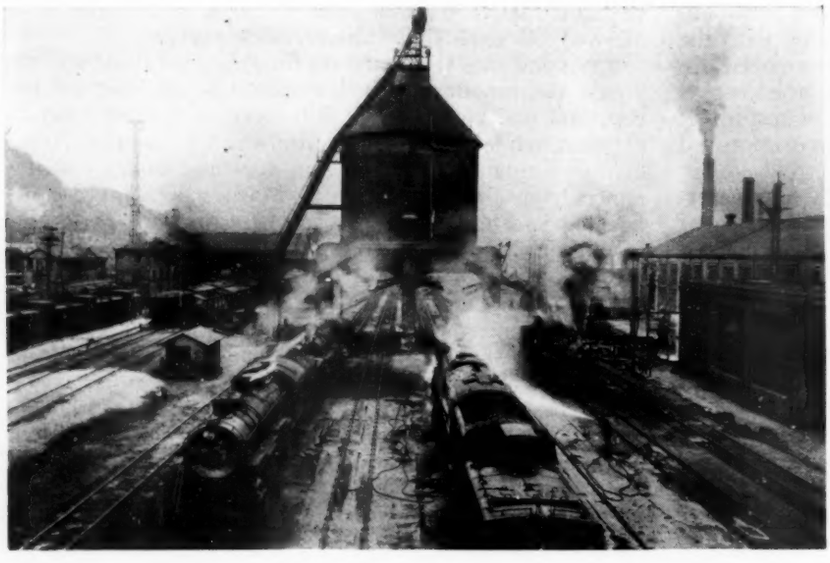
Pumping costs and maintenance have been reduced from one-third to one-half on some railroads by these improvements, and $50,000,000 per year is not considered a high estimate of the aggregate economies per year already effected by all the roads, while further advances are in prospect with the continued application of science in this field.

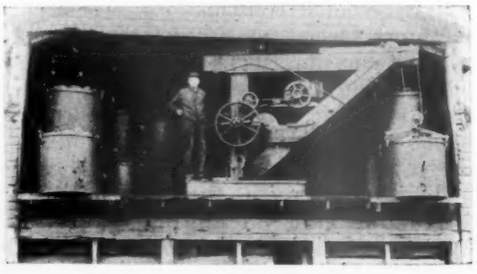
Terminals Also Have Been Greatly Improved

That terminals play an exceedingly important part in the conduct of railway transportation is well known, but the fact that research and invention have been responable for the attainment of more effective and economical service from such facilities is not so widely recognized. Evidence of the advantages of a scientific approach to terminal problems is to be found alike in the facilities for the accommodation of passengers, for the receipt and delivery of freight, for the transfer of coal and ore from ships to cars and vice versa, for the classification and forwarding of freight trains, and for the servicing of cars and locomotives. However it suffices to examine the accomplishments in one or two of these highly specialized types of railway facilities to note the progress made.

When the railroads were new, terminal facilities were naturally of a primitive character, and their development and expansion during the first half century of the railway era were predicated largely on a rule-of-thumb process founded on accumulated experience. In more recent years these improvements have been based on the results of painstaking engineering studies. More sympathetic consideration has also been given to the products of inventive genius with the result that mechanical facilities have attained an ever-increasing importance.

Mistakes have been made, but these have almost invariably been corrected in the periodic replacements demanded as the growth of traffic has rendered older installations obsolete. But growth of traffic *per se* is not the only agency responsible for replacements, for terminal improvements have almost invariably followed as a direct result of projects for the more effective movement of traffic; the urge to move traffic in longer trains, for example, has been one of the most vital influences leading to terminal reconstruction. On the whole, therefore, the railways have recast the units of their widely-scattered terminal facilities primarily to meet the demands for greater capacity and the incentive for lower costs.





A Contrast in Locomotive Coaling Stations—Above—The Primitive Bucket Hoist. At the Left—An Automatic Electric Station Serving Engines on Four Tracks, With an Engine-Washing Platform in the Foreground

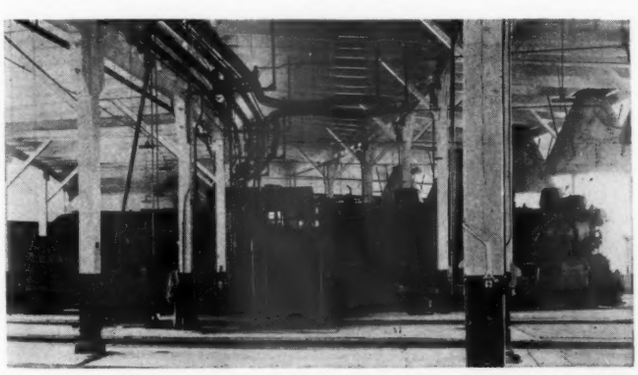
In no class of terminal facilities has the movement for improvement in design wrought greater changes than in the yards for the break-up, sorting and forwarding of freight trains. It is a long step from the flat push-and-pull yard with a few short tracks, to the modern classification yard in which three or four men, comfortably housed in towers, control the operation of retarders and power switches by means of which different cuts of cars in a long train are sorted into the various classification tracks as they are pushed over the hump by an engine a half mile or more away, and all this in accordance with a switch list made up at the yard office from the conductor's wheel report and transmitted to the towers through pneumatic tubes by the time that the road engine and caboose have been cut off.

Classification Yards

The first great advance in classification yard design took place in 1890 when the Pennsylvania introduced a hump in its Honey Point yard near Wilkes-Barre, Pa., thereby substituting gravity sorting of cars for drilling or poling. However, when this development was taken up in earnest, about 1900, it was found that many technical problems had to be solved before the idea of the hump could be generally applied. This led to an intensive study of hump grades as affected by variations in journal, wheel and air resistance, and variations in temperature, of various schemes for ladder-track arrangement, of means for the returning of car riders to the hump, and of measures for reducing damage to lading resulting from impacts. In 1924 the entire aspect of the hump yard was altered again by the introduction of the car retarder, which enables the speed of each individual car to be controlled as it passes down the ladders into the classification tracks, thereby eliminating the large number of car riders which were formerly required to ride each car or cut of cars into the classification tracks.

But the application of mechanical appliances has not stopped there. Impact recorders, for example, are not infrequently concealed in cars as a means of checking or detecting the non-observance of practices designed to minimize the rough handling of cars. In yards subjected to the rigors of severe winters, electric, gas or oil snow melters are installed at switches and retarders to insure continuity of service and obviate the expense and hazard of manual removal of snow and sleet during severe storms.

Closely allied with the classification yard is the track scale which was introduced early in railway history, but which has been subjected to marked improvement within the last few years until today cars are no longer stopped on the scales for "still" weighing by adjusting the scale beam by hand, but are weighed automatically while in



The Modern Enginehouse Is a Well Lighted Adequately Equipped Plant for the Efficient Conduct of Its Essential Functions

Yard Plans Are Invariably the Result of Painstaking Comparisons of Many Trial Layouts—Each Track and Each Switch Has Its Part in the Operation

motion and the weights recorded on tickets, without delay or manual attention and with speed and accuracy unthought of as recently as 15 years ago. Credit for refinements in design, and the perfection of automatic recording track scales, as well as of direct reading dial scales for freight houses, must be ascribed to the manufacturers, while the development of standards for the comparison of the merits and capacities of different makes of track scales and for the inspecting and testing of scales is largely the work of railway men, in co-operation with the manufacturers and the United States Bureau of Standards.

Service Facilities for Locomotives

While railway engineers and architects have been able to profit from the general advance in building design and practice in the planning and constructing of freight houses, passenger stations, power plants and shops, this has not been the case with engine terminal facilities. The roundhouse, for example, is distinctively a product of railway ingenuity. Consisting in the start of an enclosure of walls and a roof of the shape from which it receives its name, and in which work was commonly done under the handicap of poor light and a choking fog of steam and smoke, the roundhouse has become a well-lighted and adequately-ventilated building equipped with mechanical appliances for the various operations normally conducted within its walls. Drop pits equipped with hydraulic wheel hoists facilitate the removal and replacement of wheels. Power hoist-trucks eliminate heavy manual lifting in the handling of other locomotive parts and their movement to the auxiliary machine shop. Conveniently-located service outlets for steam, hot water, compressed air and electric current for both electric welding and portable power units, all make this facility a unit possessing an efficiency comparable with that found in any other industry.

No discussion of the modern enginehouse is complete which does not refer to the remarkable improvements that have been made in boiler blowdown, washout, refilling and resteaming, a consolidated process that comprises one of the most important of engine terminal operations. Not only has this process been perfected to a stage that provides for the conservation of substantially all of the heat of the water and steam that is blown out, for the heating of the water used in washing and refilling, and for the completion of the process with a minimum drop in the temperature of the boiler and firebox, but the more recently developed direct-steaming

process provides sufficient steam pressure in the boiler to permit the locomotive to move out of the house without a fire (which is started at a fire-lighting station outside). This innovation, which is designed to effect greater economy and speed in the restoring of engines to service, has, incidentally, removed the last obstacle to the attainment of the best of working conditions in roundhouse operation.

Coal—Sand—Cinders

The coaling station is another unique facility that must meet exacting and highly-specialized requirements. Starting from the primitive platform where coal was shoveled by hand into locomotive tenders, the coaling station has evolved into a plant for the mechanical handling of coal from cars to overhead delivery aprons whence it is discharged conveniently into the tenders. Coaling station designs cover a wide range, from the simple coaler without storage to the enormous plant, equipped to deliver coal to locomotives on many tracks, to provide storage and selective delivery for several grades of coal, to insure a minimum of separation or breakage, to weigh the coal as delivered and to provide parallel facilities for the storage, drying and delivery of sand.

Equal progress has been made in the improvement of the facilities for the reception and disposal of cinders, the task imposed being complicated by the fact that the cinders must be received hot from the locomotive ash pan and that quenching produces a material of distinctly corrosive activity. Development in this field has followed several different directions, and effective facilities of different makes and types are available. As with the coaling station, the railways have profited greatly from the improvement made, for not only is the operation performed with less labor and at a lower cost, and in a plant occupying far less space than was formerly required, but, especially in the case of the coaling station, there has been a reduction in the locomotive detention time for the service rendered.

Easing the Burden of Labor

Power Equipment Has Removed the Drudgery from the Laying of Rail

In no field of railway endeavor are the contrasts between pioneer methods and those of today more sharply defined than in maintenance of way work. Despite the fact that it required more than half a century to start the developments which have led to present practices and another 25 years to get them fully under way, they have advanced with such bewildering rapidity in the last two decades that at present one man is able to do as much work as 4 to 50 did formerly.

During the half century referred to, the pick and shovel were pre-eminent. Every maintenance operation was performed by hand, except the driving of piles, for which horses were used to raise the hammer. No equipment was available for easing the burden of labor, except such home-made contrivances as foremen or supervisors were ingenious enough to devise. On the surface, this lack of progress seems in strange contrast to the seething activity of the period in almost every other phase of railway development. That it was not due to lack of interest or of enterprise is evident from the fact that in 1883, at the first meeting of the Roadmasters' Association, the announcement that there was on exhibition a steam ditcher which had recently excavated 1,600 ft. of ditch on both sides of the track in a single day at a cost of only $20, was sufficient to cause a temporary adjournment of the convention to enable the members to examine it. So enthusiastically was the idea of power equipment received that upon reconvening, the association formally endorsed the machine.

Railway men and manufacturers have both been alert to the need for equipment which would not only increase the production of the individual, but at the same time decrease the burden of his labor. Progress was necessarily slow, since there was no precedent to guide the vast amount of inventive effort that was applied to the solution of these problems. Many curious and ingenious devices appeared which, through the selective process of exhaustive service tests, were gradually reduced to the relatively few machines that had sufficient merit to survive the severe demands of service and were thus considered worthy of further study and improvement.

Development Awaited the Internal-Combustion Engine

Among the earliest power equipment developed for railway construction and maintenance were the snow plow, the ballast-unloading plow and the spreader, all of which were locomotive-propelled. They were followed by self-contained machines, which carried their own power plants but had no means of self-propulsion, such as the steam ditcher, the steam shovel, the pile driver and the steam derrick. These were all heavy slow-moving machines, which in themselves had no mobility and were confined to the performance of one or at most two classes of work. This was by reason of the fact that at this time power could only be obtained directly from a steam engine. This prime mover required a boiler together with fuel and water storage, occupying a relatively large amount of space, so that it was not adapted for use in the small mobile units of the type required to conduct work along the track or right of way.

Basically, this was for years the reason for lack of

A Battery of Four Tie Adzers Does More and Better Work Than 20 Men

effective progress in this field which is sometimes so puzzling. To those familiar with the history of work equipment, it is clear that any further application of power machines or of power tools in maintenance had to await the same epoch-making development—the discovery and perfection of the internal-combustion engine—that gave rise to the automobile. It was the advent of the gasoline engine which made it possible to provide small units for maintenance operations that could be moved about at will and used for the production and direct application of power, or its indirect application by means of compressed air or electric current.

From this time, inventive genius, laboratory investigations, engineering research and exhaustive service tests have developed in bewildering array one device after another to ease the burden from the shoulders of labor, as well as to reduce the total amount of labor required to perform the work. None of these devices sprang into completed form at once. Every one is the product of long study, trial and disheartening failure, further study, redesign, exhaustive service tests, slow and laborious improvement, until they were able to give effective and efficient performance. It is only fair to say in this connection that the railways are indebted to the manufacturers for substantially all of these developments, for it has been through their initiative, persistent study and exhaustive research that they have been carried through to success.

Except for stationary service in pumping water, the first railway application of the gasoline engine was for propelling light inspection cars. Improvements in the mechanical details brought increased dependability, while accumulated experience pointed the way to units of increased power and wider application. Short as this step now seems, it required several years of development before the gasoline engine was applied successfully to a different type of car which was offered as a substitute for the hand car. Moreover, during the quarter of a century that has elapsed since this was done, manufacturers have studied constantly to improve still further in performance and efficiency both the engine and the car.

This step having been taken, other developments followed more rapidly. While the manufacturers of motor cars were striving to perfect their products and thus stimulate a wider use, others were experimenting with a wide variety of applications of the internal-combustion engine to roadway work, including such extremes as laying rail, tamping ties, driving and pulling spikes, cleaning ballast, sawing and boring timbers, adzing ties, mowing the right of way, handling material, excavating, trenching, erecting structural steel, ditching and a wide variety of other operations. As a still further indication of the wide range covered by the studies that have been made in developing this equipment, many of these diversified operations are now performed by taking power directly from the prime mover, or indirectly through compressed air or electric current, all by means of self-contained portable power units.

Specialized Surfacing Gangs with Power Tie Tampers Relieve Section Gangs of This Work

Building up the Ends by Welding Prolongs the Life of Rail

Early machines labored under a serious handicap in that they were confined to the track so that their working range was prescribed. The development of crawler mountings pointed the way to greater mobility and today there is no limit to the working range of nearly every type of roadway machine or power tool.

Other Types Were Developed

While the internal-combustion engine created a new era in work equipment, it should not be assumed that the mechanization of roadway work hinged entirely on this device. For instance, the steam ditcher and the steam shovel had reached a high degree of efficiency before this era and both made remarkable developments afterwards. The same is true of the spreader, which later evolved into a ditcher and ballast shaper. These, in turn, created a need for better hauling and unloading equipment, with the result that the flat car and unloading plow gave way to the modern ballast and automatic dump cars.

Welding by means of the oxy-acetylene flame and the electric arc have attained an important place in maintenance programs, particularly as a means of restoring battered rail ends and repairing frogs and crossings, and the use of the electric arc is extending rapidly in connection with structural steel work. This is another development for which the railways are indebted to the manufacturer, for while many of the refinements of the practices now followed have been perfected through the initiative and experience of maintenance officers and workmen, the equipment and materials as well as the basic methods were developed by the manufacturers.

Much stress has been laid on the important part played by the manufacturer in the development of maintenance of way work equipment, and it is proper that this should be done, since it is likely that few of them would have occurred without his assistance. Maintenance officers and men have not been deficient in ingenuity, while they have known rather definitely what they have wanted in work equipment. On the other hand, they have not had the requisite mechanical training to develop their ideas, or the time to do so. Neither have they had access to the shop or laboratory facilities which might have enabled them to perfect a device they had

in mind. For these reasons, it has been necessary for them to turn to the manufacturer who has the training and equipment for making the development.

An example of the wide recognition of the value of the contributions toward the solution of maintenance problems by manufacturers in this field is found in the award, made on May 17, by the Franklin Institute to the Industrial Brownhoist Corporation of its John Price Wetherill medal "in consideration of the high degree of ingenuity in design and execution of detail embodied in a successful machine for cleaning railway ballast and the real contribution it has made toward the solution of a maintenance problem of great moment."

In the development of work equipment certain objectives have always been kept in view: to increase the production of the individual, to enable him to produce with less effort, to speed up the operation as a whole and to reduce the unit of cost of the work to which the machine is applied. The machines that have survived the acid test of service have been those that attained these objectives. There have also been certain by-products of their use which were not anticipated, in that the use of these machines has brought profound changes, not only in the method of doing the work but in the organization for doing it.

Through the use of the motor car the section gang now reaches its work fresh and ready to start the day with full efficiency instead of being worn out from pumping a hand car. In the same way a rail-laying or a ballasting gang is transported to its work, and through the elimination of the work train formerly required, there is a sufficient saving to pay to the cost of the motor cars in a surprisingly short time.

Today, by means of a rail crane four men can, without undue exertion, lay 20,000 lin. ft. or more of 130-lb. rail in a day. As a hand operation, 20 men would find it a back-breaking job to lay one-fourth of this amount. By utilizing modern draglines, crawler shovels or spreader-ditchers, four or five men can do as much ditching as 200 men did formerly, and as a rule it will be done better. Likewise, modern ballast cleaners make it possible to clean and salvage dirty ballast which was formerly wasted because it was cheaper to do this than to clean it by hand. These examples could be multiplied indefinitely, and any other form of work equipment, used as an illustration, would show similar striking results.

Whereas the section gang was formerly the keystone of the maintenance organization and was expected to perform all but the exceptional jobs, more of the work it formerly did is now being performed by specialized gangs that are fully equipped with power machines and tools suitable for the class of work they are to do. They, thus, attain a high degree of perfection in this work and in the use of the particular tools with which they are equipped. On the other hand, the section gang is being gradually reduced to a policing unit which is expected to care only for the simpler routine tasks of maintenance.

While most of the work equipment in use was designed primarily to reduce the burden on labor and speed up the operation, from an economic standpoint, few such machines can survive unless they are able to demonstrate savings of sufficient magnitude to pay a satisfactory profit on the investment they represent. Illustrating some of the economies that have been effected, weeding was formerly a hand operation, slow and expensive, which required from 300 to 800 man-hours a mile and cost from $80 to $200. Today through the perfection of suitable equipment, the same track can be cleared of weeds in two or three hours by means of chemical applications or burning for as little as $3.50 to $20 a mile. Similarly, more than one road has been able to reduce its costs per mile for laying rail by as much as 60 per cent through the use of power tools, and this despite the fact that the rail is of much heavier section than when the laying was done by hand. Similar reductions have been made in applying ballast and in practically all other maintenance operations.

It is evident, therefore, that power equipment as a whole is fulfilling the purpose for which it has been devised. It is easing the burden of labor, and has resulted in a productive capacity far beyond the wildest flight of imagination 50 years ago. It has materially reduced unit costs, it is enabling the railways to do work which they could not do without it, it has raised the standards of maintenance and although a greater volume of better work is being accomplished, the actual out-of-pocket cost has been reduced.

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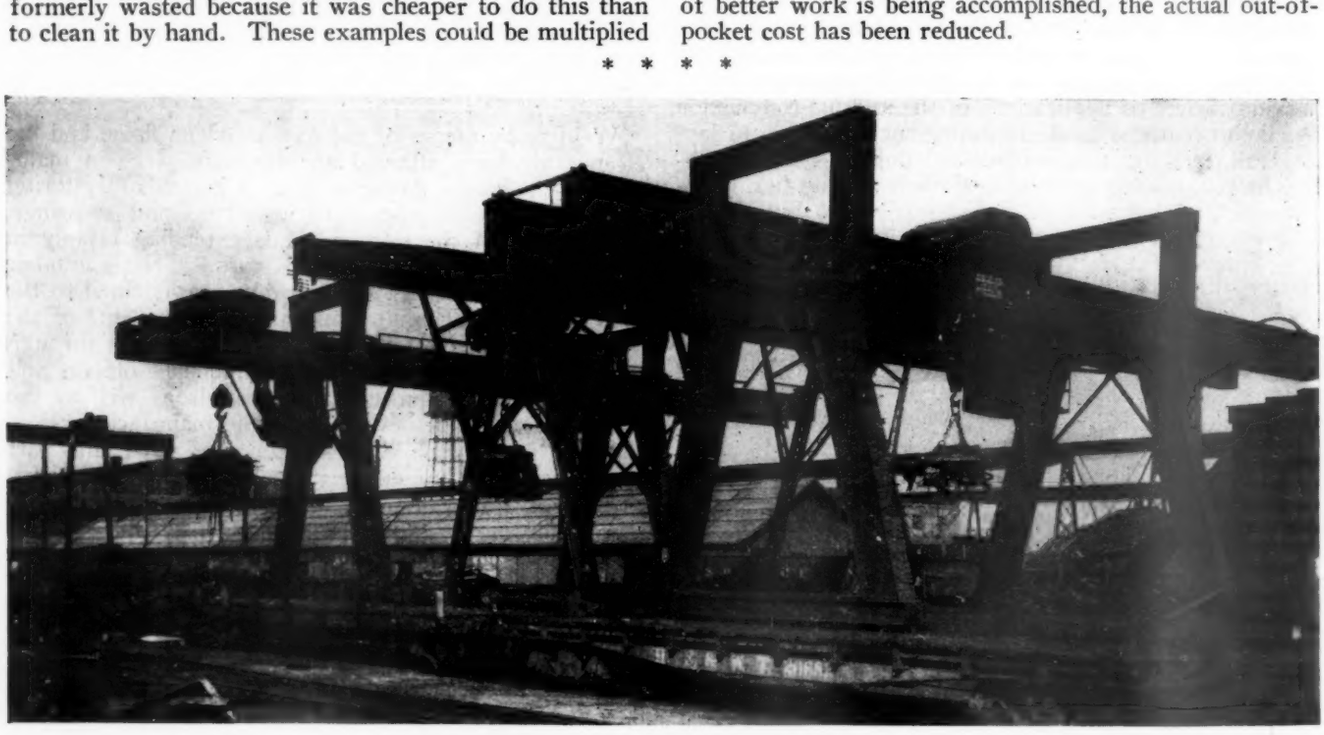


Handling Equipment in Stores Work on the Rock Island

Signaling Developments Have Improved the Operation of Trains

Railroading revolutionized by centralized traffic control, car-retarders and cab signaling during past decade

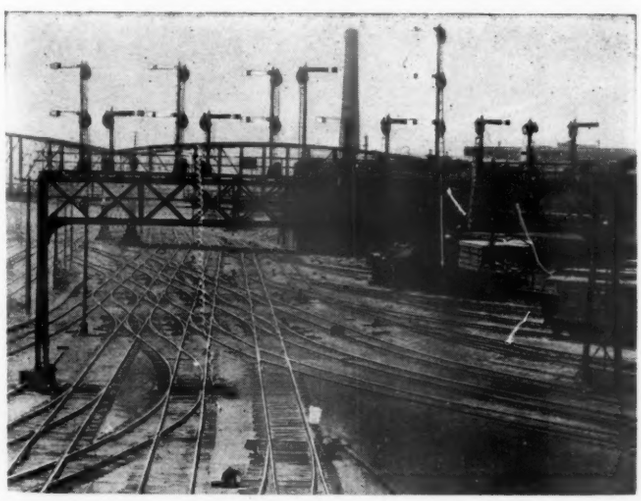
AT the time of the World's Columbian Exposition in Chicago in 1893, railway signaling, as we know it today, was in its infancy. It is true that mechanical interlocking was fully developed, having been introduced in this country about 1870. Likewise, the track circuit had been invented by Dr. William Robinson in 1873, but the use of automatic signaling was very limited. At that time such modern signaling facilities as automatic train control, cab signals, centralized traffic control and car retarders were unthought of. In fact, the past decade has seen all of these new systems developed.

Although the track circuit had been available for 20 years, the use of automatic signals in 1893 was limited. For example, one of the outstanding automatic block signal installations of that day was that constructed by the Illinois Central between down-town Chicago and the south side for the special purpose of handling passenger trains to and from the exposition grounds at Sixty-Third street. This installation employed enclosed disk signals, most of which were controlled by track treadles because cinder ballast precluded the use of track circuits, as then developed, except on a few sections.

Interlocking Developments

While mechanical interlocking was used extensively prior to 1893, the first installation of an American machine being on the New York Central at Spuyten Duyvil, near New York, in 1874, it had serious limitations as to speed of operation and distance from the tower to the switches to be operated. There was, therefore, a great need for power interlocking. Hydraulic and pneumatic systems were tried from 1876 to 1890, but were found to be too complicated and unreliable. After extensive research and development, the Union Switch & Signal Company devised the electro-pneumatic system whereby the switches and signals were operated by compressed air, while the control valves were operated electrically and controlled by circuits from the interlocking machine. The first interlocking of this type was installed in 1891 at a drawbridge on the Chicago & North Western in Chicago, and was inspected by many railroad men who attended the 1893 Exposition. About this time J. D. Taylor was developing an all-electric interlocking, of which the first installation was placed in service on the Baltimore & Ohio at Chillicothe, Ohio, in 1889. Thus, it may be said that except for mechanical interlocking, the field of railway signaling, with its numerous applications as we know it today, has been developed since the time of the 1893 World's Fair.

A. P. B. Signaling for Single Track was Introduced on the T. H. & B. in 1911



The First Important Installation of Electro-Pneumatic Interlocking Was Placed in Service in the St. Louis Union Station in 1893

Starting at that time, rapid progress was made in improving power interlocking systems. The straight pneumatic and hydraulic systems were abandoned as not practical, giving way to electro-pneumatic and all-electric. Late in 1893, the first large electro-pneumatic plant was completed at St. Louis, Mo. In 1901, the first all-electric interlocking embodying the dynamic-indication principle, was installed at Eau Claire, Wis., on the Chicago, St. Paul, Minneapolis & Omaha.

Realizing the importance of the track circuit as the fundamental control feature of block signaling, the manufacturers developed relays, batteries and bonding so that track circuits could be operated satisfactorily and economically under normal track conditions; developments in this field have been and still are of the utmost importance to the railroads.

Signal Glass a Problem

An outstanding example of the value of research to the railroads is the development of signal glass. Up to the beginning of this century, green and red were the only satisfactory colors for night signals and, as a result, red was used for "stop," green for "caution" and white for "clear." However, if a red or a green roundel was broken out, a false-clear white light was displayed, and this condition resulted in train accidents. After years of

research, the glass manufacturers developed a yellow glass of a character that could not be confused with red, and starting about 1906 most of the roads changed over to red for "stop," yellow for "caution" and green for "clear." However, work did not stop here, for the Committee on Design, of the Signal Section, A. R. A., in collaboration with one of the manufacturers and the Bureau of Standards, selected light and dark color limits and transmission values for colored glass. In 1932, the standards were transferred to the Bureau of Standards in Washington, D. C., where further calibration and development of specifications is now under way.

The Signal Itself

Another important problem was to provide a satisfactory signal. The early automatic signals were of the disk type, because no satisfactory power was available to operate a semaphore. A special mechanism attached to the base of mast, with a chain to pull the semaphore, was developed in 1893, but it was not until 1897 that the first electric semaphore, as a complete unit, was developed while the first signal with a top-of-mast mechanism was developed in 1904. Although semaphore automatic and interlocking signals have since been installed extensively, such signals display a dual system of aspects, with blades during daylight and with colored lights at night. Signals with colored lights for day and night had been used in subways, but it was not until 1910 that a color-light signal was developed which would afford adequate daylight indications under adverse conditions of strong sunlight. These signals, which were first installed on the Pennsylvania, represented the combined efforts of research and development by various signal companies, lamp manufacturers and glass companies. About 1920, a single-unit so-called searchlight signal was developed, embodying only one lamp and lens combination, the different color aspects being effected by small colored roundels in a miniature spectacle operating at the focal point of a reflector. The position-light signal, using a row of lights for each aspect, was developed and first installed on the Pennsylvania in 1915, while the color-position-light signal, using color and position together, was developed on the Baltimore & Ohio in 1921.

Early automatic signals were installed for the protection of following train movements as on multiple-track lines. Later a system employing overlaps was developed for the application of such signals on single-track lines. In order to afford absolute protection for head-on movements, as well as to permit permissive following movements for single-track lines, thus increasing the track capacity as well as affording safety, the absolute-permissive system was developed. An installation incorporating these features was installed on the Toronto, Hamilton & Buffalo in 1911.

Automatic Train Control and Cab Signals

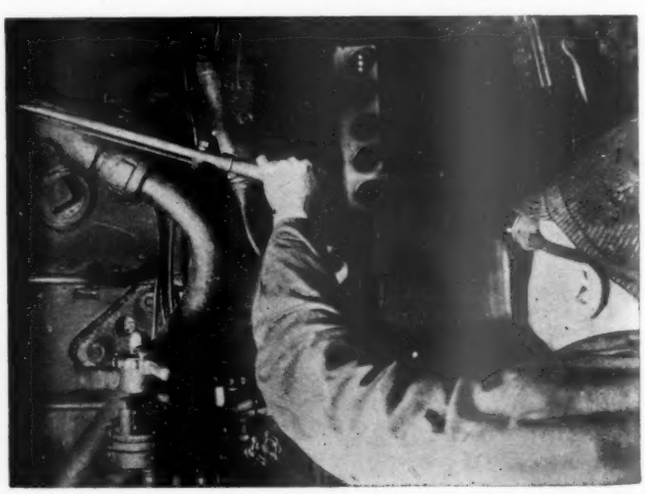
Ever since the development of air brakes for stopping trains, and of wayside signals for directing their movements, inventors had been devising schemes for connecting the two systems so that a train could be stopped automatically in case an engineman disregarded a signal indicating "stop." In 1919, the Automatic Train Control Board of the United States Railroad Administration investigated 34 train control systems, two of which were in service and in 1922, the Interstate Commerce Commission ordered 49 roads to make extensive installations of train control. It was then found that much research and development was still required and only 4 of the 34 systems were used. Later two other systems were developed and installed extensively, the continous system, with cab signaling, being an entirely new plan which grew out of intensive research and development on the part of the manufacturers to produce a system to meet the demands of the railroads.

The continuously-controlled cab-signal system was developed as an accessory to the continuous train-control system, the first installation of which was made on the Lewistown branch of the Pennsylvania in 1923. The cab-signal system, with the whistle and acknowledger has, in the opinion of many authorities, been developed until it is more useful in promoting safety of train operation than the train-control system itself. Among its advantages is the fact that the cab signals can be seen by the engineman and fireman at all times regardless of storms, smoke and fog, which frequently obscure the wayside signals.

Car Retarders

During the World War, conditions were so chaotic that little attention was given to the development of signaling facilities. Railway traffic was congested, not so much by reason of a lack of locomotives and cars as by a lack of track capacity and yard facilities. As soon as the war was over, the signaling field set about to correct these conditions and developments in car retarders, centralized traffic control and modern interlocking have been very rapid during the last decade. In brief, it may be mentioned that prior to 1920, the principal reason for installing signaling was to increase safety of train operation, whereas since that time, increasing importance has been attached to economics, until signaling installations are now authorized primarily on the basis of the savings effected by facilitating train operation and reducing operating expenses.

As a means of facilitating the operation of classification yards and eliminating car riders, the car-retarder system was developed. The first installation was made in 1924 in the yard of the Indiana Harbor Belt at Gibson, Ind. George Hannauer, then vice-president, and E. M. Wilcox, master car builder, of this road, were responsible for the development of this system, which was built of special parts, freight car springs and standard air brake cylinders, and was operated by straight air. Within a short time one of the supply companies acquired the rights to manufacture car retarders and later licensed a second signal company to do so. One of these companies developed an electro-pneumatic system of control and operation to afford the required flexibility



Three-Speed Continuous Train-Control with Three-Speed Cab-Signaling Was First Installed on the Pennsylvania in 1923

of control and retardation, while the other secured similar results by an all-electric system. The first commercially manufactured installation of car retarders was installed at the East St. Louis, Ill., yard of the Illinois Central, being placed in service February 8, 1926.

The earlier types of retarders were so exposed as to be practically demolished in case of derailments, which condition was corrected by the development of the enclosed type of retarder, while improvements were made which reduce the number of derailments. Later, rerailing arrangements were also devised. Thus the car retarder was rapidly developed to a practical and economical aid for yard operation until more than forty large yards are so equipped at the present time, facilitating car movements and reducing operating expenses varying from 18 to 40 cents per car classified.

Direction of Train Movements by Signal Indication

One of the handicaps of the train-order system is the practice of stopping trains to direct them to proceed. Staff systems or controlled manual block arrangements had been in use for years for the direction of train movements without train orders on certain sections of track over bridges, through tunnels, etc. The Erie is one of the roads that early provided remotely controlled signals to direct trains to keep moving or to take siding. However, the Missouri Pacific was the first road to

The First Centralized Traffic Control Machine Was Installed on the New York Central at Fostoria, Ohio, Only Six Years Ago

install a complete system of signaling facilities for the direction of train movements by signal indications without written train orders over an entire operating division of a steam road. This installation was placed in service in 1925, between Leeds (Kansas City), Mo., and Osawatomie, Kan., 56 miles of single track.

Concurrently one of the signal companies was cooperating with the New York Central in the development of a centralized traffic control system, wherein a dispatcher at a central point operates the passing-siding switches and signals so as completely to direct train movements. This is what is termed a unit-wire system, in which only one wire, together with the common wire, is required to control the switch and signals at the end of a passing siding, for instance, and to provide the necessary indications. The first installation of this type was placed in service on July 25, 1927, on 37 miles of single track and 3 miles of double track of the New York Central between Stanley, Ohio, and Berwick. As a means of reducing the number of line wires required

E. M. Wilcox, left, and George Hannauer, Standing on One of the Original Electro-Pneumatic Car-Retarders First Installed at Gibson, Ind., About Nine Years Ago

for centralized traffic control, another signal company later developed a system of code control, the first installation of which was placed in service on the Pere Marquette. By reason of the fact that centralized traffic control eliminates delays for the handling of train orders and reduces the number of stops at passing tracks, all train movements are expedited and fuel consumption is reduced. As a result of these reductions in delays, track capacity is so increased that peak traffic can be easier dealt with and the construction of additional tracks can be deferred for years. The same reasoning applies also to reverting to single-track operation on those sections of double-track road where present as well as anticipated traffic can be handled satisfactorily on a single track equipped with modern centralized traffic control. Because of these and other advantages, numerous roads have made installations in recent years including more than 900 miles of road, 800 power switches and 2,000 controlled signals. Freight trains are expedited on an average of more than one minute per mile and savings amount to 18 to 50 per cent on the investment, while additional savings realized by deferring expenditures for additional track facilities frequently amount to 10 to 20 per cent on the investment for the centralized traffic control.

The most recent development in the centralized control of interlocking is at Dayton, Ohio, on the Dayton Union Terminal, where the entire terminal area, including four interlocking plants and two layouts requiring switch tenders, is now handled from one centrally located machine of the C. T. C. type. This layout is divided into three sections, each of which has a separate tower or room to house all the relays and other equipment involved in the electric interlocking of circuits, simplified and combined circuits involving a minimum of wires being extended to the main control machine for control and indication purposes. These new circuits were developed by the engineers of one of the signal companies in co-operation with representatives of the signal departments of the roads involved; the Pennsylvania, the Baltimore & Ohio and the Big Four.

Automatic signals, with circuits so interconnected as to govern train movements over sections of gauntlet track, have been used at certain points for years, but it seems that such a control arrangement for the protection of a railroad crossing was first installed at a crossing of the Tidewater & Western with the Virginia Railway & Light Company at Chester, Va., in 1907. About 1922,

several roads, including the Great Northern and the New York Central, installed several automatic plants at gauntlets and crossings, the G. N. installing certain plants, including the automatic control of switches, at the ends of double track. More than 250 of these automatic interlockings are now in service, not only eliminating train stops, but also effecting net savings ranging from 20 to 170 per cent in the expenditures that in most cases are less than $10,000.

Light-Weight Cars Bring Problem

During the last few years many roads have introduced light-weight gas-electric rail cars, which are not always effective in shunting track circuits. This fact involved the reliable operation of a fundamental feature of all signaling and interlocking to the extent that either the track circuits had to be improved or the use of light-weight equipment would become impracticable. The signal manufacturers accepted the challenge and concentrated research on the problem. An arrangement with a source of alternating current on the car, fed through brushes to break down the contact resistance of the rail film, was developed by one of the signal manufacturers, while a combination of track relays, affording sensitive shunting of the track circuit, was developed by another company. As a result, the railroads now have equipment available for reliable operation of track circuits where light-weight rail cars or Diesel-electric locomotives are used.

Although used for years on electric roads, the spring switch was not practical for application to steam roads running long trains until the oil buffer was developed, about 1920, to prevent the slapping of the points between the passage of each two trucks. Even with this buffer many roads hesitated to use the spring switch because of the possibility of the point being misplaced under a train. In 1931 and 1932, two methods were developed to lock the switch points. One system incorporates a locking arrangement operated by an electric motor, while a mechanical facing point lock arrangement operated automatically by the front wheels of a locomotive, was developed by another company. The advantage of using a facing point lock is that the switch is locked in place the same as any interlocked switch so that speed restrictions are unnecessary. As a result, the opportunities for the application of spring switches have been decidedly increased.

Thus, in conclusion, it is evident that many of the problems of train operation have been solved by signaling. Yet the work continues and the manufacturers, in co-operation with the railroads, are now busy with further research and developments which give great promise of still greater improvements.

Research and Development in Car and Locomotive Materials

(*Continued from page 32*)

making and handling plain carbon forging steels has produced forgings with tensile properties from 20 to 25 per cent better than were specified 15 years ago. Carbon-vanadium and carbon-nickel steels have also been developed and are giving excellent results in service. The Union Pacific has taken a prominent part in the development of practical methods for heating and using normalized and tempered carbon-nickel forgings.

For locomotive main and side rods the situation differs somewhat from that for the other large forgings. The stresses are even more complex and it is difficult to estimate exactly what maximum stress will be reached. Consequently designers must work with a large factor of safety and have hesitated to take full advantage of the high tensile strength of the special steels. This condition is, however, not final and methods of improvement are being sought. In one project, a complete redesign of the main rod and other parts and the use of special steels is contemplated. In another experiment, which has already obtained a certain degree of success, the rods are made of a strong aluminum alloy. After extensive small-scale experiments the Aluminum Company of America applied aluminum main, side and eccentric rods to one of their freight locomotives on the Alton & Southern about six years ago. More recently they have co-operated with a large eastern road in experimenting with aluminum rods on a modern freight locomotive. It seems probable that the experiment will prove to be entirely successful mechanically and that it may be economically justifiable at least so far as the main rod is concerned.

Co-operation in research between railroad and material manufacturer has led to an interesting development of an improved white metal for lining journal brasses for cars and locomotives and lateral plates for locomotive boxes and crosshead gibs. This material consists of a lead containing from 2.0 to 2.5 per cent of alloys. It possesses the advantage of a high melting point, while its compression strength, hardness and transverse strength are approximately 50 per cent greater than those of the standard A. R. A. lining metal.

The New Car Materials

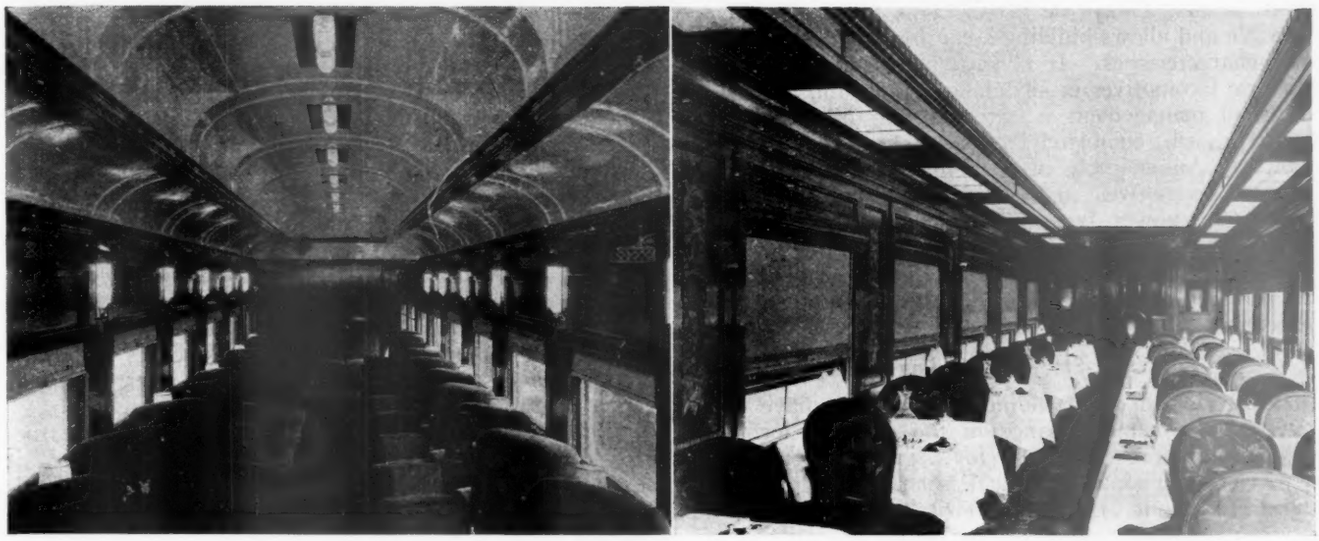
In the structural steel plates and shapes generally used for the framing and body of passenger and freight cars there is not much opportunity for the use of special steels. The possible reduction in weight would hardly justify the increase in cost. In certain special car designs high-tensile stainless steel is being tried in an extreme effort at weight reduction. A drawback here is the loss of stiffness with the very thin plates. Time will decide on the success of this attempt. At present it can be reported that the railroads are studying the possibilities.

Another experiment which is of great interest is the use of aluminum for the construction of freight and passenger cars.

The strong alloy of aluminum has a yield point of from 35,000 to 46,000 lb. per sq. in. and a tensile strength from 58,000 to 61,000 lb. per sq. in. Sections approximately the same as those required with mild steel can therefore be used. The resulting car structure will be less than half the weight of a similar steel structure.

If subjected to heavy shocks, the aluminum, because of its low modulus of elasticity and greater deformation for the same load, is capable of absorbing considerably more shock energy than a steel structure of equal strength. The manufacturers' research work in establishing the proper alloys to give sufficient strength and the large amount of development work in ingot practice and in rolling-mill operation before plates, shapes and forgings of railroad size could be produced would require an individual paper to themselves.

For the progress in materials which has been reported we are indebted to a thousand alert minds who, while making and using car and locomotive materials, have been constantly seeking methods of improving them. The record is not closed. The good work continues.



Present-Day Lighting is in Large Measure Responsible for Passenger Comfort and Beauty of Car Design

Electrical Energy in Railroad Service

Economic conditions have not retarded electrical developments— Many new transportation facilities provided

PRACTICALLY no railroad activity, be it operation, maintenance or engineering, is now carried on without the aid of electrical energy. Its inherent adaptability, promoted by the energy and genius of those who have worked out its practical applications have made it one of the essentials in providing present-day railroad service.

Electric Traction

Electric traction was first applied to steam railroad service in 1895. Its development has been most rapid in the last few years and almost within the period of the depression its capabilities have been tremendously increased. New alternating-current traction motors have been developed, at the insistence of railroad engineers, by the large electrical companies. These motors are capable of applying 1,250 hp. continuously to driver rims, and, due to improved commutation, voltage control makes this power available at practically all operating speeds; no longer does power drop off rapidly at high speeds. These locomotives require high axle loads, but similar motors have also been developed which permit of distributed axle loads. The same species of motor has permitted doubling the power per axle on a.c. multiple-unit cars; this reduces equipment costs by allowing an increased use of trailers.

Motor control developments have gone hand in hand with improved motor design and with equipment now available it is possible to control traction motor currents from the primary side of the locomotive transformer; this simplifies the control and effects a net saving in weight of about three tons on a 3,000 hp. locomotive.

Three thousand-volt, direct-current, multiple-unit cars, a short time ago considered impracticable, now provide excellent suburban service. Mercury-arc rectifiers supply dependable 3000-volt power to these cars without the support of rotary apparatus. Grid-control of the rectifiers provides automatic voltage regulation. Numerous other applications of grid control are in process of development; one of these will probably result in the use of rectifiers as static frequency changers.

High-speed circuit breakers and extensive research work done in conjunction with telephone and telegraph companies has practically eliminated the old bugaboo formerly called inductive interference and now referred to as inductive co-ordination. These same breakers, monitored by relays, almost instantly disconnect any part of the power supply system which may be in trouble and isolate it from the remainder of the system. Substation breakers can be and are now relied upon to protect the locomotives, thus relieving the crowding of apparatus on the locomotive and reducing total costs.

The "De-ion" principle, as applied to circuit breakers, has tremendously increased the value of currents which can be interrupted and has also increased the permissible number of operations without inspection and cleaning.

The effect of lightning on transportation systems is now dealt with scientifically. Guess-work has been removed and lightning brought under control. Knowledge of the behavior of lightning has made it possible to design transformers which are virtually lightning-proof.

Power supervisory systems have been made available through which all switches on a system may be controlled and the condition of the circuits indicated to a power supervisor.

Outdoor substations serve to reduce the cost of power supply; it has been found practicable, not only to place transformers, switches and lightning arresters out-of-doors, but also to house rotating apparatus in sheet metal housings and eliminate a major part of the station building costs.

Gas and Oil-Electric Cars and Locomotives

Gas and oil electric cars as used in the United States require power plants of such size that electric drive

must almost always be used. This drive is extremely flexible and allows building a car for any desired operating characteristics. It is particularly effective for oil-electric locomotives in switching service and at least one railroad management is satisfied that oil-electric locomotives will completely replace steam for switching power. An example of flexibility is offered by three-power locomotives in switching and transfer service; these take power from the contact system in transfer service and develop their own power for switching. Operation shows that nine times as much power is used in transfer as in switching, but the locomotive operates efficiently for both purposes.

Electric Welding

Electric and gas welding and cutting have almost revolutionized maintenance in the car and locomotive shops and serve effectively for a great variety of purposes in the maintenance field, such as building up battered rail ends, frogs and switches, applying bonds, strengthening bridges, etc.

In the structural field, welding has been shown to be more economical than riveting for certain types of buildings and in any case provides a much stiffer structure than is possible with riveting. As applied to factory or shop buildings employing trusses welding greatly reduces structural costs. It is also most effective and economical for making additions to existing steel structures.

Welding machines are now made for a great variety of purposes and in capacities to meet the greatly increased rate at which it is now possible to make welds. Improved electrodes have been primarily responsible for the increase in welding speeds. Worn piston heads, driving-wheel centers, cross heads, etc., are now built up by means of automatic welding. Mobile tractor welders on caterpillar treads, powered by gasoline engines make it possible to take the welder to practically any place where work is to be done and also supply grinders for finishing, and light with which to work at night.

In the manufacturing field, fabrication of machines and of cars has greatly reduced foundry requirements and allows for making special equipment at relatively low cost. A form of spot welding, known as "shot welding" has made possible the construction of light-weight stainless steel cars.

Motors and Control

In recent years, control apparatus for motors and power circuits has been placed in service which completely protects the operator from accidental injury. It also protects the motor from injury by improper operation. Motors are available for every conceivable application, from the reversing planer motor, which eliminates the use of belts, to the high frequency motor which has created entirely new possibilities in the field of portable tools.

One of the most recent developments is the totally-enclosed motor which, without increase of size, can be used in all manner of railroad applications where dust, grit and moisture are encountered. Such motors with new types of switch gear, known as explosion-proof, can safely be used in grain elevators, lacquer rooms and other hazardous locations.

Totally-automatic and semi-automatic control apparatus for pumping plants has been developed to meet a large number of railroad requirements. No-fuse protection for motor and lighting circuits serves materially to reduce costs and to insure against interruption of shop operations.

The enginehouse not equipped with a crane type tractor for handling rods, front ends, air pumps, etc., is exceptional. Load-carrying trucks and tractors for hauling trailers have become indispensable for moving materials in railroad shops and terminals and for handling freight at transfer points.

Motors without commutators, having almost any desired characteristic, are being developed along with grid-controlled rectifiers. Their early applications will probably be for large size motors and it is possible they will have an important influence in the heavy traction field, eliminating entirely the now relatively unimportant question of system.

1250 Horsepower Per Driving Axle

Electric Heating

Electric heating has not found wide application, but its value has been proved and those who have used it for the melting of babbitt and pouring of journal bearings consider it indispensable. The accuracy with which it can be controlled makes it highly desirable for many kinds of heat treating and its use will almost undoubtedly be greatly increased.

Power Factor Correction

Studies made by railroad electrical engineers have disclosed many possibilities for the saving of electric power through the consolidation of services, revamping of contracts, reduction of peak loads, and the introduction of capacitors or permittors. These equipments, which can be supplied in relatively small sizes, are placed at strategic points so as to reduce the flow of wattless current and correspondingly reduce the size of feeder lines, transformers, generators, turbines and boilers.

Power Plants

For a long time it has been evident that power could, in most cases, be purchased by the railroad more cheaply than it could be generated and it has been a widely

Electric Heating Insures Heat Treating Results

adopted policy to use purchased rather than generated power. Now, however, bleeder type turbines are available in practically any desired size, a factor which gives the railroad an excellent opportunity to bargain with the power supply company, particularly when the location has use for low pressure steam for heating or other purposes.

Air Conditioning

Air conditioning of railroad passenger cars promises to be an effective means for attracting passenger traffic. Successful operation of such equipment is essentially a matter of power supply and equipment has been developed which is adequate for this purpose and which will supply as much as 15-kw. of electrical energy from the car axle. Paradoxically the principal manufacturer of carlighting equipment has developed a steam-ejector system of air conditioning which receives power for refrigerating purposes from the train steam line. Air-conditioning systems not only reduce temperature and humidity in hot weather, but also supply heat and moisture to the car in cold weather. They provide for improved ventilation and quiet operation, all of this being made possible by electric thermostatic control.

Lighting

Specially developed lighting facilities are now available for practically every railroad application, including passenger stations, enginehouses, shops, freight houses, offices, yards, cars, locomotives and all manner of miscellaneous facilities, many of which could not be lighted by any other means. Data have been developed to show quantitatively how much can be expected in the form of improved operation and reduced accidents by proper lighting.

The Mazda lamp manufacturers have instigated research which has been of inestimable value to the railroads: lamps cost only one-fourth of what they did 20 years ago; average lamp efficiency has since 1908 been increased from 3.5 to 13.5 lumens per watt; after 1000 hours burning lamps still give 90 per cent of their original candle power; in the past ten years the number of defective lamps has been reduced from the small value of six-tenths of one per cent to less than one-tenth of one per cent. Cost of electric power has also declined and it has become decidedly uneconomical to work with inadequate light.

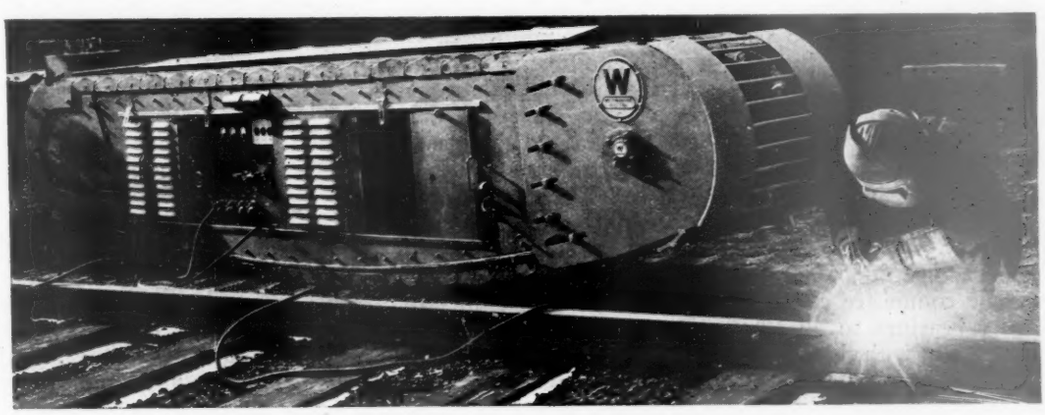
New artistic and compact car lighting fixtures, made to conform with the design of the car, add materially to the appearance of the interior without detracting from the effectiveness of the lighting. Gear and Vee-belt positive generator drives have been developed which insure continuous power supply to these lights and reduce or eliminate yard and terminal charging of car batteries. The Vee-belts are available both as continuous and open-end belts; the latter are equipped with strong durable fasteners and have been adapted to both body- and truck-mounted generators of various sizes up to 15 hp.

New Fields for Electrical Apparatus

Photo-electric cells are used for a great variety of purposes and a railroad man recently showed how such equipment could be used for alining movable railway bridges, thereby providing, if desired, for remote operation.

A communication system for trains, employing the running rails and any convenient wayside wire, without interference with its other functions, has been recently demonstrated. It will probably be used for communication between the head and rear end of long freight trains, between nearby trains, and between trains and wayside points.

Recent experiments have shown that extremely high-frequency radio signals operate over short ranges only and do not cause interference with important radio channels. This method offers another possibility of short-distance communication. Similar short waves are also being employed experimentally by a railroad to exterminate the weevils which destroy wheat and other grain. They do this effectively without damage to the germinating qualities of the grain. The annual loss due to train spoilage, which the process aims to eliminate, is two billion dollars annually.



Electric Welding Anywhere

Mechanical Division Holds Limited Meeting at Chicago

At an open session, the General Committee hears and discusses the report presented by the chairmen of the standing committees

IN lieu of the customary annual meeting held each year in June by the Mechanical Division of the American Railway Association, the meeting this year was confined to an open session of the General Committee, held at Chicago on June 27, at which chairmen of the standing committees and a few other members were present and at which the reports of the standing committees were presented. Although full committee meetings have been somewhat curtailed during the past year, the reports as a whole indicated that the work of the association has made definite progress during the year. Fifteen reports were presented.

Report on Locomotive Construction

The report of the Committee on Locomotive Construction was divided into a consideration of 10 subjects, including the counterbalancing of locomotives, high-pressure pipe fittings, advantages of high boiler pressure, oil-electric locomotives, application of steel tires to wheel centers, locomotive springs, injector details, a study of failed parts of locomotives, roller bearings for locomotives and tenders, and the use of stainless steel in locomotive construction.

The recommendations of the committee regarding the details of locomotive construction mentioned were developed as a result of careful investigations during the year by subcommittees and will have an important bearing on improved locomotive performance. In that part of the report devoted to high boiler pressures, a summary was given of existing experimental installations and attention was called to the advantages of stainless steel for valves and valve seats; also of nickel-steel plates for boiler construction, which provide the requisite strength with approximately 30-per cent reduction in weight.

In connection with the development and use of oil-electric locomotives, the committee presented additional operating statistics for the year 1932. One table showed the results obtained with ten 300-hp. oil-electrics operated in railroad service at an average cost of $2.35 per hour, exclusive of depreciation and fixed charges, this cost being reduced to $2.21 per hour with a one-man crew. Similarly, the average operating cost for four 600-hp. oil-electrics was $3.05 per hour. The committee called attention to the reduced terminal conditioning expense with oil-electric power and said that its adaptability as regards clearances, concentrated weight, ease of operation over sharp curves, quick acceleration and absence of smoke, recommends it for switching service, especially when the steam power employed has reached a service life at which it is due for replacement by new power in the interests of reduced maintenance and more economical operation.

The committee called attention to the adaptability of roller bearings to all locomotive and tender axles. In connection with the present application of roller bearings to engine-truck axles on 432 locomotives on 12 railroads, the committee reported as follows: "A study of these installations leaves no doubt as to the decided improvement in service obtained, in freedom from hot boxes, elimination of hub-heat checking, reduced cost of lubrication, inspection and maintenance in general, and increased safety. Aside from the initial cost of application, it does not appear that there can be any legitimate excuse to order new power without roller bearings, at least in the engine trucks, and it is evident from replies received that the extra cost is entirely justified by better locomotive performance and subsequent economies in operation."

Referring to driving-axle bearings, which have been applied to six locomotives on four roads, the committee said: "While the application of roller bearings to locomotive driving axles presents a more difficult problem than to the engine truck, the improvements to be gained are even more important and desirable."

The committee also called attention to possible future applications of roller bearings to other parts of locomotives than to the axle mentioned. It referred to the development of roller bearings for side and main-rod applications; also to valve motion parts, in which it is hoped to reduce the lost motion due to wear, curtail maintenance expense and secure more accurate steam distribution. The committee expressed the opinion that an increasing number of new locomotives will be equipped with roller bearings.

Report on Car Construction

The Car Construction Committee reported on the present status of the five sample steel-sheathed wood-lined box cars, which are now being constructed by the Pressed Steel Car Company, a member of the American Railway Car Institute. As soon as they are completed, these cars will be subjected to certain static and impact tests and then placed in operation on a number of roads in order to obtain additional performance data in actual service. The committee reported that it is working on the design of standard 50-ton and 70-ton self-clearing hopper cars under the same program of procedure which was followed last year in designing the steel-sheathed box car, and that work on a projected standard refrigerator-car design will be held in abeyance until the preceding work is completed.

The committee also submitted recommendations regarding various details of design, such as truck springs, spring planks, rail-motor-car axles, brake beams and heads, center plates, box-car door fixtures, hand brakes, steel castings, safety chains, etc.

Couplers and Draft Gears

This committee reported that a total of 11 applications for approval tests of draft gears were received from six manufacturers. Ten complete or partial tests were made at the American Railway Association draft-gear laboratory at Purdue University under the imme-

diate supervision of the A. R. A. draft-gear engineer and, as a result of these ten tests, certificates of approval were granted covering the following types of gears for freight service: Waugh-Gould Type 403, National Type, M-17-A, Cardwell-Westinghouse Type NY-11-E, Miner Type A-22-XB, Cylinder D-7935, Miner Type A-2-XB, Cylinder No. D-7940 and Cardwell Type L-25-SA.

The committee recommended the insertion of a new paragraph in the standard specifications, covering test set-ups and definitions, and also recommended that road tests be undertaken as soon as business conditions permit, for the purpose of ascertaining the effects of draft-gear recoil in long trains and to investigate the Duryea and the Alma cushion underframes and draft gears of selective-travel type.

The committee also recommended revised coupler contours for the standard Type-E coupler, which promises an increase in coupler strength of 5 per cent, wear limit for various parts up to 40 per cent, gathering range 15 per cent and provide an increased factor of safety.

Report on Brakes and Brake Equipment

At the 1931 meeting of the Mechanical Division, the Committee on Brakes and Brake Equipment submitted proposed details, dimensions and specifications for the No. 2 plus brake beam. The purpose was to make the beam standard in all details, as well as in outlining dimensions and specifications. In the discussion at the meeting, objections were raised to certain details. There was a particularly insistent demand for an increase in certain dimensions of the brake head to provide greater resistance to brake-head and brake-shoe wear. Following the meeting, the matter was referred back for joint consideration of several interested committees and subsequently, after certain revisions, a proposal was submitted to letter ballot and defeated.

In this year's report, the committee again submitted proposals after joint consideration with the manufacturers for a standard to be known as the No. 15 brake beam, which differs from the No. 2 plus beam in that it has a deeper strut. It also includes modifications in the brake head and shoe to effect greater resistance to wear and modifications in the steel back of the shoe to reduce the tendency for brake-shoe breakages. Drawings submitted with the report give complete details of the proposed No. 15 brake beam.

Report on Wheels

The Committee on Wheels has for years been working closely with the manufacturers of the various types in the development of designs and manufacturing processes to improve the reliability and economy of wheel service. This year's report records progress in this continuing phase of the committee's work, in the conduct of which, it has co-operative relations with the Association of Manufacturers of Chilled Car Wheels, Association of Steel Manufacturers' Technical Committee and the American Standards Association.

A year ago the committee was requested to develop information to show the mileage made by various types of wheels. As a result of many years' studying of this phase of wheel service, the committee has found so many difficulties in the way of securing information for satisfactory mileage comparisons that it is endeavoring to enlist co-operation of the members of the association in securing data relating to the defects which cause the removal of wheels from service, rather than to attempt the almost impossible task of establishing an average mileage life for all types of wheels in all types of service. Toward this end, the committee has devoted itself to the development of the table of symbols for wheel defects and forms for recording and classifying the defects which cause removal. This information, it is believed, when analyzed, will form the basis for constructive action toward further improvement in wheel service.

Loading Rules, Prices and Rules of Interchange

The Committee on Loading Rules worked during the past year on the important task of simplifying the rules and, at the same time, reducing the size of the book of rules. With those objectives in mind, the general rules were rewritten, effecting a saving of 50 per cent in the number of words. The work of revision is not yet finished, but the complete revision is expected to be in the hands of the secretary in time for publication on or before January 1, 1934.

In order that the rules covering the prices for labor and material may provide an equitable basis for interroad billing, the committee on this subject continued the work of analyzing costs and recommending necessary changes in the rules of the freight- and passenger-car codes, with a view to determining and recommending necessary changes to be made in the supplement, effective August 1, 1933.

The Arbitration Committee reported decisions on 19 cases during the year, namely, No. 1702 to 1720, inclusive, copies of these decisions being made a part of the report.

Lubrication of Cars and Locomotives

In reporting on the subject of car lubrication, the committee stated that notwithstanding the forced curtailment of operating expenses during the past two years, there has been a continued improvement in hot-box performances, mileage records upwards of 800,000 miles per failure being no longer uncommon in freight service. The committee called attention to the continued successful use of all-year car oil by a number of roads in various parts of the country and advocated a more extensive use of this oil in the interests of further reductions in hot boxes. The committee presented recommendations regarding the testing of oil for impurities. As regards locomotive lubrication, the committee made specific recommendations regarding the lubrication of cross-head guides, brake and spring rigging parts, etc.

Automotive and Electric Rolling Stock Reports

The Committee on Automotive Rolling Stock reported that 763 power rail cars were placed in service between 1923 and 1931, the average horsepower per car steadily increasing from 97.5 in the former year to 446 in the latter, indicating that the demand for light motor cars has steadily decreased. The committee commented on the importance of maintenance, which will be covered more fully in next year's report.

The Committee on Electric Rolling Stock reported progress in a study of factors affecting pantagraph design, maintenance and operation. It stated that no new electrification projects were started during the past year, but that a total of 62 electric locomotives were placed in passenger service and two electric locomotives in freight service between New York and Philadelphia, Pa., on the Pennsylvania. The major part of the report was devoted to a consideration of methods of cleaning traction motor equipment in place on locomotives and methods of cleaning ventilating air before passing through the equipment.

Other Reports

For the Joint Committee on Automatic Train Line Connectors, H. A. Johnson, director of research, re-

(*Continued on page 69*)

Purchases and Stores Division, A. R. A., Considers Year's Work

G. E. Scott
Chairman

Ready to co-operate with co-ordinator-sentiment of one-day meeting held behind closed doors in Chicago

W. J. Farrell
Secretary

IN place of an annual convention which it was decided not to hold this year, the General Committee of the Purchases and Stores Division, American Railway Association, met with the chairmen of the subject committees on June 25 in Chicago to receive the reports of the work accomplished during the year and to take such action as was necessary to continue the work and make the information available to members, pending the next convention of the division. Approximately 60 purchasing and stores department officers and supervisors were in attendance at this meeting, including Chairman G. E. Scott, vice-chairman C. B. Tobey and Secretary W. J. Farrell. There being no election, these officers will continue to hold office until the next convention. The meeting was held behind closed doors and certain of the business was not made public, but the problem of railway co-ordination was obviously one of the chief concerns of the members. M. J. Gormley, president of the A. R. A., attended the meeting, and the general sentiment appeared to reflect a readiness to co-operate in the co-ordination work.

Increased Efforts to Secure Adoption of Recommendations

That an increasing effort is being made by the division to secure a more general adoption of its recommendations was evidenced by a paper which U. K. Hall, general purchasing agent of the Union Pacific, had been called upon to prepare for the meeting. "While in an organization such as ours," Mr. Hall said, "it is not possible, and probably not desirable, to attempt to issue obligatory instructions, when a subject has been carefully considered by a committee of our division and recommended as standard practice, then put to a vote in convention after surviving discussion on the floor of the convention, we should seriously consider whether any of the members or representatives of the individual roads have the moral right to set up their own judgment against the judgment and vote of the convention." Among the recommendations of the division mentioned were the complete segregation of the departments of purchasing, handling and disbursing of materials and supplies from the using departments; also the adoption of a standard stock book or stock record and a standard material classification.

A report of the Committee on Stores Statistics, presented by O. A. Donagan, general storekeeper, Boston & Maine, carried the announcement that a joint committee of accounting and supply officers has been formed for the purpose of making a detailed study of stores expense on at least three railroads.

A report presented by C. R. Painter, purchasing agent, New York, New Haven & Hartford, suggested that shipping notices should be standardized and made of the same size and form as the simplified invoice. It was also reported that 500 forms have been supplied with the telegraphic code and that the secretary of the division will endeavor to have the Postal Telegraph Company and the Western Union Telegraph Company include the telegraphic code in their code books. The use of this telegraph code, the report stated, effects an average saving of about 27 per cent in telegraphic expense.

In an extended and detailed report on the subject of reclamation, a committee of which J. J. Collins, general foreman, scrap and reclamation plant of the Erie, was chairman, advocated the development of centralized shops for reclaiming roadway tools and made the following statement in support of its views as to the economy of centralizing the handling of scrap:

> Certain railroads have found that, by centralizing their scrap at one point, they have been able to recover good material without repairs amounting to as much as 6 to 12 per cent of tonnage handled. It is estimated that the value of this material is between $50 and $75 per ton. A railroad handling 20,000 tons a year, based on 6 per cent, saves 1,200 tons of good material at $50, resulting in a saving of $60,000 in the purchase bill. This, of course, does not include certain items of material that are picked out for reclamation. Then too, the scrap prepared would net an average of at least $1 to $2.50 a ton, effecting further savings of between $20,000 and $38,000 as a result of preparation and increased prices. One railroad presented figures indicating that by centralizing its scrap handling at one point, and by preparing its scrap, it was able to increase the percentage of mill scrap from 73 per cent to 99 per cent, obtaining an increased revenue of $25,000 as a result of preparing 10,600 tons of scrap which was sold as yard scrap before.

Reports released for publication, subject to approval or revision at the next convention are presented in part below, with the exception of the papers of the winners of the annual essay contest and certain incomplete reports which will be published in later issues.

Material Guarantees

M. E. Towner, Chairman*

After canvassing the field for information as to the practice being followed, the committee decided that there should be a written expression, clearly defining the responsibility of manufacturer, producer, agent, contractor, or such parties as supply the material. The guaranty may be limited, that is, limited responsibility of the guarantor, or full and complete, which binds guarantor to a full and complete warranty. It was pointed out that manufacturers who fully guarantee their products are primarily liable, under the law, for material failures of any nature. The form or wording of the guarantee should be left to the particular railroad making the purchase or the contract wherein material is specified, bearing in mind the ability of the guarantor to fulfill the terms and conditions. It was also pointed out that some guarantees cover a long time period, such as 10 years or more.

So far as is possible, the guarantee should be specific as to what constitutes a failure, inherent or otherwise, of the particular item coming under the guarantee. In case of failure, a complete statement of facts should be promptly obtained in order to handle with the vendor.

Many railroads, as well as many manufacturers, have a definite list of materials to which a definite material guarantee is applied.

While it is true that specifications, either manufacturer's or purchaser's, and a guarantee are usually separate, it is equally true that within the terms of contracts specifically applying to the purchase of materials, reference is at times made to "the described material" made in accordance with "defined specification herein and is guaranteed to, etc."

In the case of a guarantee such as may now be regularly offered and accepted, attention is called to clearly defining the manufacturer's responsibility beyond ordinary inspection and as applying to hidden defects.

Direct Results from Indirect Purchases

Christian M. Woodward†

Left to themselves, contractors will purchase material at the lowest price obtainable among the sources of supply known to them, with little or no attention to method of delivery, or appreciation of the railroad's peculiar relation to manufacturers or sellers. The purchasing agent, in his effort to wield the maximum influence of his experience for the greatest benefit to his railroad, should control these purchases.

Construction contracts are known as "lump sum," "unit price," "fee" and "percentage" contracts and involve a combination of two or more of these types. In preparation of all such contracts, elements of flexibility should be included to insure the full benefit of the purchasing agent's action. A clause should provide for co-operation between the contractor and purchasing agent, and, in "lump sum" or "unit price" types of contract, a credit to the railroad equal to any cost reduction effected through the purchasing agent's efforts. "Fee" and "percentage" contracts, by their nature, will reflect the savings developed by the purchasing agent's procedure.

Buying Contractors' Supplies

Every contract, of whatever type, should be worded to permit the railroad to furnish the contractor any satisfactory material which the former may have as surplus, with appropriate credit.

It is important that materials entering into construction work be of the best, and nearly every railroad has time-tried specifications for many of the required items. These specifications should be incorporated in the contract or other adequate standards should be substituted. Thus the practice of approximating specifications by the use of a manufacturer's name is avoided, and the scope of supply sources correspondingly widened, with a proper proportion of the railroad's interest fully maintained. For those items which are not covered by any specification, submission to the contractor of the railroad's approved list of manufacturers or sellers will serve as an adequate safeguard.

A brief outline of the several salient steps in such a plan of buying is as follows:

The engineering department, upon requesting bids for a given project, sends to the purchasing agent a copy of the invitation, the specifications, list of prospective bidders, and the approximate cost, followed by a copy of the award when made. The contractor then prepares for the engineer-in-charge a list of the kinds and quantities of materials required for the general contract and sub-contracts, a copy of which is sent to the purchasing agent for his recommendation as to prospective sources of supply.

From his records and experience, the purchasing agent submits to the contractor the names of the firms who should be requested to bid, with the understanding that the contractor may supplement such a list by adding the names of any other firms he may desire to include. Upon receipt, the bids are tabulated by the contractor, and submitted to the engineer-in-charge, who transmits them to the purchasing agent with the recommendations of the contractor and himself.

The purchasing agent, after consulting with the stores department concerning the possibility of furnishing the material from railroad surplus, considers all phases of the transaction, involving the point of origin of the material, f.o.b. point, point of use, price, quality, delivery, ability of the prospective seller, and other pertinent factors. A joint decision is reached and the contractor is then authorized to complete the transaction.

Purchases and Traffic

Keen competition, particularly with the current decrease in volume of purchases, often impels a seller to claim that the railroad's purchases of his product have been negligible. It is equally frequent that purchases by a contractor from that seller, for railroad work, have amounted to a considerable sum, and, in such a conference with vendors and potential shippers, the purchasing agent's record of these indirect purchases is a potent argument. Furthermore, a direct increase in revenue accrues through insistence by the purchasing agent that materials for such projects be shipped by railroad.

The maintenance of quality is an important result of this procedure. It is doubtful that the contractor's knowledge of the performance of materials and apparatus, under actual working conditions on railroads, can equal that of the railroad's engineering and mechanical departments, and consequently, the purchasing agent's experience, his consultation and prior knowledge of the requirements and specifications of the engineering and mechanical departments of his railroad, are factors in efficient operation that cannot be safely ignored.

Handling Materials

J. G. Stuart, Chairman*

During the past year, there was a further tendency to concentrate material in fewer locations and points of distribution and in this way decrease the handling cost as well as the amount of material carried. In a number of cases, it has been found economical to discontinue supply trains and substitute supply cars handled in local trains. These supply trains or supply cars are now making a distribution every 60 days instead of 30 days. Other roads are loading "sailing" cars at specified times during the month. The material in these cars is distributed to stations, sections, pump-houses, roundhouses, small repair tracks, etc. The material is properly way-billed, loaded in cars in station order and scheduled for certain trains, and the schedules are published so that everyone interested will know the approximate time of arrival of the trains. The material is handled by the train crew the same as they handle other local material. In some cases, these cars are returned to the store with all of the old material gathered along the line, such as track tools, empty oil drums, oil cans and bad-order or surplus material of all kinds.

Various types of skids have been developed for loading particular classes of material. Where a large quantity of oil is shipped from the distributing point to some other point, tanks holding up to 500 gal. can be built on skids, which makes it possible to handle 500 gal. on one skid.

Further development is suggested in delivering material around large terminals. When material is furnished from a general store and shipped to large treminals, the material for all departments can be loaded into one car and sent to one location and

* General Purchasing Agent, Western Maryland.
† Office of Purchasing Agent, Pennsylvania.
* Assistant Purchasing Agent, Chicago, Burlington & Quincy.

from that location the balance of the material is distributed to the various locations by truck, avoiding delays to cars and the extra switching of cars, and permitting delivery of the material to its destination in less time. Several railroads have developed a trucking service under the stores department, which does practically all of the hauling in and around large terminals, including the hauling of men for master carpenter work, for car repairs at out-of-the-way places, and for replacing derailed cars on track where it can be done without calling out the wrecker.

The committee recommended that special effort be made to find the machines, equipment or methods best suited to the particular condition. A careful check of the cost of the work should also be made and a careful estimate of the cost under the proposed new methods. Two examples are as follows.

Example No. 1

Statement of savings effected by the purchase and use of one lift-type electric truck, one hand lift truck, 190 skids and wood boxes for stores department. Period of operation, October, 1929, to May, 1930, inclusive.

Former Facilities		
4 blacksmith helpers .....183½ days at $17.60	$3,229.60	
2 material handlers .....183½ days at 7.52	1,379.92	
Car-department tractor .....183½ days at 2.25	512.87	
Delivering 503 tons brake beams at $.20 per ton....	100.63	
Former cost		$5,233.02
Present Facilities		
1 electric lift truck, 1 hand lift truck, 10 steel trays, 139 skids and 85 tops. Cost of installation.....		$4,712.23
Operator .....183½ days at $4.32	$792.72	
Recharging cost .....183½ days at .66	121.11	
Oil and grease .....183½ days at .05	9.18	
Present cost		$923.01
Interest at 6 per cent on investment of $4,712.23...	$188.49	
Depreciation of 15 per cent on investment of $4,712.23	471.22	
	$659.71	
Previous cost	$5,223.02	
Present cost	923.01	
Saving	$4,300.01	
Carrying charges	659.71	
Net saving	$3,640.30	

Per cent of savings:
3640.30 77 per cent on 8 months or
4712.23 115 per cent per year

Example No. 2

Proposed installation of lift trucks and skids.

Proposed Equipment		
1 power lift truck 2 hand lift trucks (single) 3 hand lift trucks (mult.) 400 skids		$7,650.00
Annual Carrying Charges		
Interest on investment.....at 6 per cent	$459.00	
Depreciation on $3,000.....at 20 per cent	600.00	
Depreciation on $4,650.....at 15 per cent	697.50	
Repairs .....at 5 per cent	382.50	
	$2,139.00	
Annual Operating Costs		
1 operator at $.50 per hr.....	$1,224.00	
Annual carrying and operating charges.....		$3,363.00
Proposed Savings Based on Working Six Days Per Week		
1 tractor operator.....at $.50 per hr.	$1,224.00	
6 laborers .....at $.35 per hr.	5,140.80	
Total annual saving		$6,364.80
Less annual carrying and operating charges.....		$3,363.00
Net saving		$3,001.80

This makes a gross saving of 83 per cent, or a net saving of 39 per cent, after deducting all of the operating and carrying charges. This equipment was authorized and purchased and, after having been in service over four months, a report was made showing that the actual pay-roll saving was equivalent to $7,320 a year.

Exchange of Surplus Material

A. W. Munster, Chairman*

The committee recommended in 1932 that each railroad adopt an efficient unit in its purchasing and stores organization for the control and sale of surplus materials primarily to other railroads; that accurate and completely-described items of materials by classes should be circularized; prompt shipment to be made after sale, and a confidence between the carriers developed by assuring that material subject to consignee's inspection at destination would be as advertised.

At a meeting in New York on January 13, 1933, it was recognized that satisfactory results could only be obtained if all of the using departments were instructed to co-operate to the fullest extent in making use of new or second-hand materials, ready for service, secured from other railroads. This co-operation could only be obtained through the approval of the plan by the presidents of each railroad.

The plan was placed before the Committee on Elimination of Preventable Waste of the Presidents' Conference in the Eastern Territory and resulted in the issuance of a circular dated February 23, 1933, by the Presidents' Traffic Conference—Eastern Territory, that the following practice be observed by Eastern railroads:

"That carriers in the Eastern region currently circularize lists of surplus materials according to A. R. A. Classification with accurate and complete details and specification references.

That railroads receiving such lists check them carefully against their needs and purchase such surplus materials from other carriers to the greatest practical extent.

The surplus new materials are to be sold at 75 per cent of the current market price, and the second-hand materials ready for service at 50 per cent of the current market price of similar new material; the market price to be the current cost f.o.b. line of road of the seller; materials to be sold f.o.b. the nearest junction point of the purchasing railroad; terms of payment to be 30 days net after receipt of invoice.

The material is to be shipped subject to inspection at point of origin or destination as may be agreed upon by seller or purchaser.

With the reduced purchases, very little material has been sold between railroads, but the committee recommended that the Presidents' Conference groups in the other territories be advised by the president of the American Railway Association of the action taken in the Eastern group, and that all railroads be instructed to put the plan into effect for the sale and purchase of surplus materials between railroads.

* Vice-President, Boston & Maine.

Stationery and Printing

J. T. Van Horn, Chairman*

Expenditures made for stationery and printing by Class-I railroads for the past six years were as follows:

1927.....$26,840,000	1930.....$32,100,000
1928..... 25,638,000	1931..... 21,680,000
1929..... 25,567,000	1932..... 15,320,000

It was recommended that railroads should adopt two grades of printed letterheads, one for executive departments and one of a cheaper grade for all other departments to be used exclusively for outside correspondence, and that plain paper should be used for all inter-departmental correspondence. The size of all letterheads, as well as second sheets, should be 7½ in. by 9½ in.

Reports received from various railroads indicated that a substantial saving is being accomplished through the adoption of a 7½-in. by 9½-in. size for printed forms as well as letterheads. Railroad A reported that over 300 forms have been reduced to this size. Railroad B reported a saving of $527 through the adoption of this size for a number of forms, as well as all letterheads. Railroad C reported the recent adoption of this size letterheads and the intention to apply it to various forms as they are reprinted. Railroad D has adopted this size for inquiry as well as order blanks. Railroad E has changed 65 forms to this size, as well as to size 4¾ in. by 7½ in. Railroad F has changed 24 forms to this size. Railroad G has changed 393 forms to this size. These changes have been made without violating Railway Accounting Officers' Association regulations regarding the adoption of size 8½ in. by 11 in. for waybills and other forms.

The committee secured samples of trip passes, trip pass requests, courtesy pass requests, personal expense account blanks, postage stamp requisitions and register stickers from the member roads. Six samples of trip passes received were different. It was recommended that size 3 in. by 5 in. be adopted. Trip and courtesy pass requests and personal expense account blanks were also various sizes, and it was recommended that these forms should not exceed 7½ in. by 9½ in. This also applies to purchase order forms.

On the majority of railroads, printed tariffs are the largest single item of expense on stationery and printing account. The committee endeavored to secure comparative cost figures from railroads who print tariffs in their privately-owned printing plants, and those purchasing them from outside printing and planographing concerns. One railroad reported an average cost of $2.47 per page per 1,000 copies for 14,598 pages of composition comprising 33,505,000 printed pages. Another railroad has all tariffs planographed by an outside concern at an average cost of $2.77 per page per 1,000 copies for 5,645 pages of compo-

* Stationer, Missouri Pacific.

sition, comprising 8,152,000 printed pages. Of this total, 2,588 pages of composition were written by the railroad and finished for reproduction, at a saving of 58 cents per page.

One member line is furnishing mechanical pencils free of cost to employees in certain departments. Another road is contemplating adopting this plan. Another road has been selling mechanical pencils to their employees at cost, and supplying them with the leads free of cost. During the years 1929 and 1930, this road's consumption of No. 1, 2 and 3 wooden pencils was 4,025 gross and the consumption of leads was 245 gross tubes, with 18 leads to the tube. The total cost was $8,513. During the years 1931 and 1932, the consumption of No. 1, 2 and 3 wooden pencils was 915 gross and the consumption of leads 192 gross tubes, 24 leads to the tube. The total cost was $2,574, a saving of $5,938, as compared to previous two-year period. The 1931 and 1932 total combined cost was $323 less than the total for the year 1930 During the four-year period, it sold to employees 12,538 mechanical pencils, ranging in price from 10 cents to 30 cents each.

Inventories and Material Marking

U. K. Hall, Chairman*

The committee prepared a questionnaire which was sent to various railroads, and a general synopsis of replies received, is as follows:

Inventory

On what date do you take annual inventory? The replies showed that a preponderance of the roads take their annual inventory on October 31 and that the majority of the roads take their annual inventory at one time. On some roads, certain classes of materials for the entire road are taken at the close of the various months' accounts, thus continuing the operation throughout the year instead of taking it at one time, although under this method all materials are adjusted during the fiscal year period. Under this method the inventory average or shortage, as adjusted throughout the year's period, does not seriously affect operating expenses at any one time. This also spreads the work out over a greater period of time and does not upset the organization to take care of the work at one period.

Where the inventory is taken at one time, any adjustment affects the operating accounts, and where the inventory is taken near the close of the year, the amount has to be disposed of before the end of the fiscal year and may seriously affect the operating expenses of the closing months. However, an argument for taking the inventory at one time is that the organization is arranged so that the work is compiled and completed at once, and the work finished.

It was also found that some roads stagger their inventories by taking a complete inventory of various divisions or territories during specified months in the fiscal year. This, of course, can only be done where a separate balance sheet, by divisions or territories, is kept, in order to permit the balancing of the inventory as against the material on hand accounts.

An argument which most roads present in favor of taking inventory in the latter part of the year is that generally the maintenance of way program is completed by that time, and the inventory does not interfere with the work, and that a more accurate inventory is thus obtained.

What special or general preparation is made prior to inventory time? The answers to this questionnaire developed the fact that on most of the roads, practically no special preparation has to be made for materials at store points, where stocks are in a condition to be counted at all times.

As to line stocks, a number of roads hold meetings with superintendents and the heads of using departments review the inventory with instructions received from the auditor, ascertain the condition of the stock, discuss any questions pertaining to the accounting and listing of such stock, and thus assure that the stocks are in a condition to be quickly and correctly inventoried.

What method of listing is used? It was found that there are three methods generally used for listing materials; namely, the inventory card, the inventory form, or listing the material in the regular stock books. The latter method can only be applied to store stocks, as items of line stocks are not listed in stock books. Where stock books are used, it is necessary to use a form that will permit the pricing, extending and compiling of totals. Some roads use blank cards and blank forms, writing in the description of the material when the count is made. Some have cards and forms typewritten in advance from the stock book or from the previous inventory record. Where bin pricing is in effect, all quantities are entered and prices noted at the same time,

If any class of material, such as locomotive fuel, rails, ties, etc., or other large or special classes is inventoried more often than annually and the result used for adjusting the material and supplies balance, state dates upon which each such inventory is taken for each class and if the material-on-hand accounts are adjusted accordingly. Of the roads reporting, 46 take no trial inventory between inventory periods, but depend upon the annual inventory for any adjustments. A number of roads take such inventory of fuel, cross ties, rail and other large items at stated periods and the accounts are adjusted throughout the year's period, thus preventing any large fluctuations at the time of the annual inventory.

Is inventory taken of all unapplied materials and supplies, including material at shops, enginehouses and repair points, material on line in custody of using departments, and all usable second-hand material at all store points? Of the roads answering the questionnaire, 68 take an actual inventory of all unapplied materials and supplies at small shops, enginehouses and repair points, where the material is in the custody of the using departments and all usable second-hand material at such points is also inventoried and listed. Some roads charge out the material shipped to these small points at the time the material is shipped and do not carry it in the material-on-hand account or take it into the inventory.

What class of employees do the counting and listing of the items on the inventory records? The replies indicated that stores department employees count all stocks in custody of the stores department and at small mechanical-department points. A number of roads report that the accounting department assists in the listing of such items.

Where and by whom are these inventories priced, extended and completed? Of the roads replying, 46 handle the inventory entirely by stores-department organization, while 24 handle it entirely by the accounting department, and 26 railroads list and price the inventory in the stores department, the final extensions, compilation and adjustments being handled by the accounting departments.

What method is used in connection with prices applied to inventories? Are the prices based on actual cost, plus freight charges paid foreign line, or are current market prices prevailing at the time inventory is taken, applied? The replies developed that prices are based on the actual cost plus foreign freight charges, discounts, etc., on 93 railroads, while the prices are based on prevailing market prices at time the inventory is taken on three railroads. Practically all roads are taking into consideration all items entering into the cost of materials; that is, the purchase price, freight charges paid, discounts deducted, etc.

Who renders final compilation showing net results? The replies indicate that the stores department renders the final compilation on 38 railroads; the accounting department on 53 railroads; and the stores and accounting departments, jointly, on 3 railroads.

Who conducts the investigation and renders explanation as to adjustments? The committee developed that the adjustment and explanation is rendered by the auditor on 21 railroads; by the purchasing and stores departments on 46 railroads; and jointly by the auditing and stores departments on 23 railroads.

Who is held responsible for taking inventory of material and supplies at smaller points in charge of the using departments? The replies developed that responsibility for taking inventory at smaller points rests predominately with the stores department, stores forces supervising the account and listing the materials. The net results show 49 railroads where the stores department performs these tasks, 34 by the using departments and 5 where it is done by the auditor.

Are complete inventories written in detail on sheets by machine or by hand, and how many copies are made? Replies to the questionnaire show that complete inventories are written in detail on sheets, as follows: By machine, 62 railroads, the number of copies ranging from one to eight; by hand, 11 railroads, the number of copies ranging from two to three; by machine and hand, 11 railroads, the number of copies ranging from two to 25. Two railroads reported that the inventory is written on cards, only one copy being made. On one railroad, the inventory is photostated, one copy being made.

Answers to questionnaire developed that 21 railroads use the numerical marking system and 69 railroads do not use it.

Conclusions

The majority of the committee favored taking inventory at one period of the year, preferably either September 30 or October 31. It was further recommended that the counting, listing, pricing and classification of materials shall be performed by the stores department forces. Irrespective of who computes and completes

* General Purchasing Agent, Union Pacific.

the inventory, the pricing and classification should be done by the stores department. It was further recommended that inventories should be taken, listed, priced and extended on an inventory sheet and this sheet, as used on inventory day, should serve as the final compilation of the inventory. It was also recommended that trial inventories of certain classes of material, such as fuel, rail, ties, wheels, axles, lumber, etc., be taken at designated periods throughout the year as conditions warrant, and adjustments made accordingly.

Fuel Purchasing

J. M. Johnston, Chairman*

The consumption of coal and oil, including direct freight charges of Class-I steam railroads, amounted to $162,679,868 in 1932, compared with $214,672,466 in 1931, resulting in a decrease of 24.2 per cent. Net tons of coal consumed by locomotives in 1932 amounted to 66,193,456, as compared with 81,231,867 in 1931, a reduction of 18.5 per cent. Barrels of oil consumed totaled 41,448,976 in 1932, as compared with 47,430,386 in 1931, a reduction of 12.6 per cent.

The average cost of coal consumed in 1932 was $2.05 per ton, including direct freight charges, compared with $2.16 per ton in 1931, a reduction of 5.09 per cent The average cost of fuel oil consumed in 1932 was 65.1 cents per bbl., including direct freight charges, as compared with 73.5 cents per bbl. in 1931, a reduction of 11.4 per cent.

The following tabulation shows the trend of fuel performance of Class-I railroads for a five-year period:

	Pounds of coal per 1,000 gross ton-miles, including locomotive and tender	Gross-tons per train, excluding locomotive and tender
1928	127	1,837
1929	125	1,866
1930	121	1,870
1931	119	1,809
1932	123	1,683

Although the unit consumption in freight service in 1932 exceeded the 1931 performance by four pounds per 1,000 gross ton-miles, the train load was lower than in any year since 1925, indicating that the low train load handled in 1932 was largely responsible for the increase in unit consumption.

The factor of train speed, which has been steadily rising, must be considered in analyzing these figures. For the year 1932, the average speed of freight trains was 15.5 m.p.h., compared with a speed of 14.7 m.p.h. in 1931, an increase over 1931 of 5.5 per cent.

In 1920, locomotive fuel constituted about 13 per cent of total railroad operating costs, while for 1932 this was reduced to 6.69 per cent. The cost of fuel was, of course, a large factor in bringing about this reduction, but conservation methods contributed in a great measure to the decline in operating costs.

Fuel Oil Standards

In the report for 1931, it was suggested that a standard fuel oil specification be adopted by all oil-burning railroads, but, in view of retrenchment on many railroads, it was not deemed advisable to continue this subject, although the use of oil in 1932 represented 13.5 per cent of the total fuel used. The Department of Commerce, Bureau of Standards, Washington, recently addressed a letter to producers, distributors and users of fuel oil, stating that the revised commercial standards for fuel oil have been accepted by the majority of oil refiners, distributors, and consumers, as well as many of the oil-burner manuufacturers and, accordingly, may be considered effective May 1, 1933. This will prove of great benefit to users of fuel oil and the adoption of these standards will insure more uniform specifications.

The Supreme Court has ruled that the Appalachian Coals, Inc., may continue its operation as a centralized selling agency for coal producers in Kentucky, Tennessee, Virginia and West Virginia. This decision is not only important because of its application to the coal industry, but because it may affect a number of other basic industries, such as oil. While additional revision of the law is still needed, the decision should assist in solving some of the difficulties of many important industries. The first thing such sales agencies should do is to adopt a marketing policy which will result in fair, consistent and reasonably regulated profits and prices to the consumer.

Investigation of fuel purchasing practices, known as Ex Parte 104, carried by the I. C. C. in 1932, has been terminated, but the final conclusions reached by the examiners have not yet been made public as far as the committee is aware.

The past year has seen production in all lines at low levels and the railroads have labored under difficulties because of poor business conditions. The question of fuel is prominently identified with operating expenses, and, while great strides have been made in efficiency and purchasing methods, renewed efforts are necessary if operating costs of the railroads are to be reduced.

* Fuel Agent, Missouri-Kansas-Texas.

Manufacturing in Railroad Shops

G. J. Hunter, Chairman*

The control of stock manufactured in the shops is in no way different from the control of material purchased in the open market. Both are based on actual requirements, predicated on consumption, as indicated by the stock books. Proper consideration should be given to shop production costs so that no item will be manufactured unless it can be done at a cost equal to, or better than, the market price.

It has been recommended that the quantities ordered should be as large as possible, consistent with quantities usually carried in stock. This is important in the control of material manufactured in the shops for stock. It appears that a manufacturing plant must operate at approximately its capacity if the most economical results are to be obtained, and that when production falls below 80 per cent of the rated capacity, manufacturing ceases to be economical.

Accounting in Repair Shops

The committee considered "manufacturing facilities" under two headings: (1) Material manufactured in repair shops and (2) material manufactured in separate manufacturing plants. Both facilities are subject to Interstate Commerce Commission accounting practices in so far as the "charge-out costs" are concerned. However, when comparing such costs with current purchase prices, an additional "overhead charge" must be added to the shop-order cost. Where separate manufacturing plants are maintained, proper cost accounting can be set up, taking into consideration every item of cost. This has not been done in the case of material manufactured in shops primarily engaged in the repair of locomotives and cars. Where material is manufactured in repair shops, the cost includes (1) material, (2) direct labor and (3) shop expense.

The item of "shop expense" is a proportionate part of the items covered by I. C. C. Account 600, which includes: Pay of department foremen and their clerks; pay of assistant department foremen and their clerks; pay of chauffeurs and oilers; pay of sweepers, cleaners, etc.; pay of unskilled laborers employed in general work in and about shops and shop grounds; pay of watchmen, gatekeepers and policemen at shops and repair tracks where mechanical work is done; pay of employees attending fire drills; pay of employees repairing or having charge of small shop tools.

Power: Cost of fuel in power plants, oil, waste, etc.; pay of stationary engineers and firemen; pay of electricians, coal handlers and other employees engaged in power production; cost of picks, shovels and other small tools; cost of water purchased.

Heating: Cost of fuel and supplies for heating shops.

Lighting: Cost of current, gas, oil, torches, incandescent lamps, etc.

Switching: All expenses, including wages, fuel and supplies of switch engines exclusively assigned to switching service at shops.

Shop Supplies: Includes fuel for forges, small tools, lubricants and all supplies generally used in shop work.

Incidental Expenses: Watchmen's clocks and call boxes; removal of snow and ice from shops and shop yards; ice used in shops; and all other undistributed shop expense.

Cost Accounting Imperfect

It is evident that railroad accounting, as prescribed by the I. C. C., can not show accurate manufacturing costs, and as a factor for controlling manufacture, it is misleading, many items of overhead being entirely disregarded.

In the year 1921, the I. C. C. inquired into the question of whether carriers were justified in entering into contracts for repairs to cars and locomotives with outside shops, and decided that railroad overhead could be disregarded because the railroad facilities were available for use, and no saving in overhead expense could be shown due to contracting the work outside. This opinion is supported by many members of Division VI. The committee does not concur and recommends that a reasonable percentage of overhead expense be added to the shop-order costs when comparing them with prices quoted by outside manufacturing concerns. What this percentage should be, the com-

* Traveling Material Supervisor, Atchison, Topeka & Santa Fe.

mittee is not in a position to say. It has been variously estimated at from 60 per cent to 100 per cent of the direct labor charge.

Costs in Special Shops

Where strictly manufacturing plants are maintained, it is recommended that the following items be used in determining manufacturing costs: Direct labor, material and overhead, the latter including supervision, shop expense, store expense, repairs to buildings, repairs to machinery, repairs to tracks, interest on investment, depreciation of tracks, buildings and machinery, insurance and employers' liability, pensions, death benefits, freight charges and taxes. These captions are comprehensive enough to include every item of cost and, when properly applied, should result in a shop-production cost fairly comparable with those of other manufacturing concerns.

Six per cent appears to be a reasonable rate of interest on investment, and should be figured on the depreciated value.

The depreciation charge should be based upon the percentage of the original cost (estimated, if not known), determined to be equitable by experience as to the actual current loss from depreciation. Depreciation should cease when the difference between the ledger value and the estimated salvage value shall have been credited to the accrued depreciation account.

Some railroads add another charge for "general administration expense," which, in one instance, is figured at 1½ per cent of the direct labor. When any item of extraordinary expense is relatively so large that its inclusion in the costs for a single month will seriously distort such costs, it should be distributed in equal monthly charges to the remaining months of the current year.

A questionnaire was sent to 25 of the larger railroads, in order to develop what principal stock items were being manufactured in their shops. The items reported were:

Bolts—machine and carriage
Bolts—engine
Bolts—stay
Bearings—journal
Cushions—caboose
Curtains—storm
Castings—brass and bronze
Castings—grey iron
Cattle guards
Chisels
Forgings—car and locomotive
Frogs and switches
Frog and switch material
Flags
Nipples—pipe
Pins—coupler knuckle
Pressed steel parts for locomotives and cars
Pipe—concrete
Pilots—locomotive
Rings—piston and valve
Rivets—coupler yoke
Rods—Locomotive main and side
Screws—set
Studs—boiler
Shoes—brake, freight and passenger car
Springs—locomotive
Studs
Tinware—all kinds
Washers
Wheels, cast-iron car

Classification of Material

R. G. Bensen, Chairman*

During the year a survey was made to determine the extent to which the Standard Material Classification is being used. The replies indicate that 62 railroads, with 124,428 miles of track, use the American Railway Association Material Classification in its entirety; that 12 railroads, with 21,963 miles of track, use the A. R. A. Material Classification in part; and that 20 railroads, with 76,533 miles of track, use material classifications of their own design. The general objection expressed to the Standard Classification is that it is too elaborate and expensive. Other railroads have not adopted it because of the expense involved in changing forms and educating employees to its use.

The material classification adopted in 1910 was based on the use of the material and, for that purpose, the classification was divided into four groups, namely, maintenance of way, maintenance of equipment, conducting transportation and general.

In 1925, the committee reported a general sentiment for a reduced number of classes and recommended that the subdivision of classes could be changed or revised to meet the needs of the individual roads, but that the primary classes should be followed. In 1930, the committee recommended the elimination of this note from the classification, and in 1931 and 1932, additional items were added to the index and the classification was brought up to date.

Recommendations

The committee considered that the most important thing today is to hold the ground already gained so that comparisons of stock balances may be made in a uniform manner. In view of the objection of some roads to using the classification on account of its being too elaborate and too expensive, the committee recommended that consolidations be permitted which will not destroy the basic principle of the classification; it also recommended that all roads keep their material account at least sufficiently in detail to provide the figures required by the committee on Subject IV—Comparisons of Material Stock Reports and Store Expenses, for the material stock report.

* Classification Inspector, Erie.

Purchasing and Storekeeping for Highway Vehicles

R. C. Harris, Chairman*

The committee has confined its activities to the detailed operations which lend themselves to standardization, as follows:

Local studies of fueling costs to determine whether the fuel-oil supply should be obtained direct from dealers or from manufacturers and then stored, must be sufficiently thorough to demonstrate which method of delivery of fuel and lubricants is most economical. Filling-station deliveries of gasoline are usually considerably more expensive than deliveries from company-owned facilities; therefore, the co-operation of all departments should be obtained to arrange schedules and facilities in such a way that the major portion of the fuel requirements will be obtained from company-owned facilities which will permit tank-car or tank-wagon purchases.

Storage facilities having a capacity of 12,000 gal. can, at present prices of labor and material, be installed at a cost varying from $1,500 to $2,000, including interest on investment, annual depreciation, annual cost of operation of pumps for discharging and annual freight charges. Experience shows that fueling points will change and it, therefore, becomes necessary to consider that possibility before permanent storage facilities are installed. It may be practicable to find a reliable lubricating company with whom a term contract may be made for supplying all lubricants required and the tools and facilities for applying those lubricants. A contract of this kind should only be made with a company able to furnish all lubricants required for all purposes, thus making it unnecessary for the motor-coach company to carry any stock.

Purchasing Repair Parts

In the automotive field, the necessity for the user to carry a large stock of repair parts does not generally exist, largely because the manufacturers of the standard coaches maintain service points in all large industrial centers. Purchase arrangements with those companies will make unnecessary the carrying of large stocks by the coach companies. While an arrangement of this kind may appear to restrict competition, the changes in design by the manufacturing companies are so frequent as to make doubtful the economy of opening the purchases of important repair parts to unlimited competition, until the designs become stabilized. The necessary guarantee on parts purchased also has an important bearing on this feature of the service of supply. On the other hand, there are other parts such as gaskets, bolts, nuts, washers, packing rings, etc., manufactured for the trade which can be purchased in the open market considerably below the price quoted by the manufacturers. It should, therefore, be the constant aim of the purchasing department to increase the variety of parts purchased in the open market as fast as reliable products can be found at attractive prices.

The highest turnover in material occurs where the stores representative is accurately informed of the needs of the user and is familiar with the requirements of the service. It is believed that stores representatives should be specialists in that kind of material in order to serve the needs of the users with the smallest investment practicable.

Simplification of Stock

The same ordering practices that have been found effective by railway supply organizations will be found effective in handling motor-coach material, with the exception that the small protective stock carried must be counted and replenished more frequently. The blanket order plan can be extended with safety beyond the limits desirable with railroad materials because the sources of supply for many items of motor-coach material are limited. This plan reduces the stock carried and, if carefully supervised, should not result in the payment of higher prices. Under this plan, the material is shipped only as actually needed and is not held in stock.

Odometer readings should be recorded for all material removed from automotive equipment purchased under a guarantee or which has been found defective, even though not purchased

* General Storekeeper, Pennsylvania.

under a guarantee. These readings should appear on the charge-out slip forwarded to the purchasing or stores department. Each case of replacement should be handled on its individual merits.

It is unwise to invest in equipment for heavy repair work when the volume of repair work is small, unless the nearest outside facilities are so far away as to make such installation imperative. Automotive repair plants having volume output should generally be able to take motor-coach work at a lower price than that at which the motor-coach company could do the work. The value of reclaimed crank-case oil is still a matter of controversy among engineers, but there is some reason to believe that reclaimed oil from which all foreign matter has been removed is not only as good as new oil, but, in some cases, is better for crank-case use.

Two methods for tire repairs are available. One is where a tire manufacturer or his agent will agree to supply all tires needed by the coach company at a specified price per vehicle-mile and will furnish all equipment and labor for removing and applying tires at specified points. Under this plan, the tire company maintains at its own expense, tires mounted on wheels ready for application. The other method contemplates the purchase of tires outright by the user, in the same manner as for other material. The relative merits of the two plants depend upon the location and the possibility of finding a reliable tire service company which has the organization to supply tires as needed at a price lower than that at which the coach company can supply its own requirements.

Purchases of Special Devices

P. L. Grammer*

Special restrictions should be imposed on ordering repair parts for special devices in advance of actual requirements, particularly for new devices. It will be found less expensive, in most cases, to stand the inconvenience of waiting for repair parts rather than to order too liberally. Among the methods which could be followed to advantage in determining the relative cost of special devices is a comparison of the cost of all the parts with the purchase price of a complete unit; also an analysis to determine if the repair parts might be manufactured by the railroad itself, or bought from some other manufacturer than the one marketing the complete machine.

Where bearings are required, the manufacturers of bearings, in addition to the manufacturers of complete unit, should be asked for prices. Where motor-driven tools or equipment are required, prices should be obtained on the complete equipment and for the tools or equipment, less motors and controls, and competitive prices on these items should be obtained from the manufacturers of motors and electrical equipments.

In purchasing repair parts for special devices which may be covered by patents, railroads should protect themselves against any possible claims for alleged patent infringement.

As an example of the savings which can be made by a careful analysis of repair parts for special devices and adequate competition before purchases, two roads reduced costs of such materials by approximately $188,250 during one year.

Contracts

Formal contracts ordinarily should not be made for periods of less than 90 days, or for more than 6 months. Exceptions to this rule in some cases are rail and fuel. Price contracts for special devices and materials such as airbrake material, signal materials, etc., should ordinarily be made on an annual basis. Manufacturers should not be asked to make up special materials and supplies for prompt deliveries as required unless covered by formal contract agreements, clearly defining the purchaser's obligations to take such materials and supplies within a given period.

Prompt replenishment is always an important factor in keeping down to a minimum the general working stocks carried at local and general stores. As one of the methods to accomplish this end, it is recommended that all roads give consideration to release order system as described in 1932.

Definite specifications or commercial standards are available and in many cases, essential in the purchase of various classes of materials. They permit wider competition with consequent price reductions and provide for all bids to be submitted on the same basis. It is, therefore, recommended that standard specifications recommended by the American Railway Association, also commercial standards, including those promulgated by the Federal Specification Board, be carefully studied by all roads with a view of having them adopted in place of special specifications wherever practicable.

* Assistant Purchasing Agent, Pennsylvania.

Opportunity for Rail-Highway Co-ordination

WASHINGTON, D. C.

ALTHOUGH the federal co-ordinator of transportation is operating under a law directly applicable only to railroads and their subsidiaries, and although there has been some criticism because the problem of co-ordinating the various forms of transportation has been postponed for further study and later legislation, the new Special Board for Public Works has suggested one method by which, through co-operation between the new public authorities, some co-ordination of transportation may be effected without so much delay. Moreover, plans which have been advanced for organization of the motor truck and bus operators to take advantage of the provisions of the national industrial recovery act by the adoption of codes relating to wages and hours of employment, fair practices and possibly tariffs, may pave the way for a stabilization of highway transportation in such a way as to make possible some degree of co-ordination between rail and highway transportation which has been difficult to accomplish under conditions as they have existed.

Rules and regulations promulgated by the board for the allocation to states of the $400,000,000 provided under the terms of the new law for highway and related construction include a provision by which not more than 25 per cent of the funds apportioned to any state shall be applied for a time to secondary or feeder roads, not now included in the federal-aid highway system, "which are either part of the state highway system or are important local highways leading to shipping points, or which will permit the co-ordination or extension of existing transportation facilities, including highway, rail, air, and water."

After setting up a basis for determining priorities for the various projects the regulations also provide that "the Secretary and the Board reserve the right to require the construction of roads desired by the U. S. Railroad Co-ordinator to provide adequate year-round highway service in replacement of branch-line railroad service proposed to be abandoned."

Authorization for the abandonment of railroads must still be obtained from the Interstate Commerce Commission under the interstate commerce act and the co-ordinator is given no authority on that subject, but it is believed that his recommendations or support may have an influence on the extent of such authorizations and the availability of highway service would in many instances have an important bearing on the extent to which railroads may effect economies by curtailing their own service and expenditures. The possible importance of this aspect of the economy problem is indicated by the fact that in less than six months of this year the railroads have already applied to the Interstate Commerce Commission for authority to abandon nearly 1,100 miles of line, and in the year ended October 31, 1932, the commission authorized the abandonment of 1,418 miles.

In the selection of projects to be included in the programs for highway construction to be submitted to the federal board by the state highway departments, the rules state that priority shall be given as follows:

"(a) the closing of gaps in the federal-aid highway system; (b) the appropriate landscaping of parkways or roadsides on a reasonably extensive mileage; (c) the correlating and supplementing of existing transportation facilities by road, rail, air, and water, and providing of

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LIMA A-1

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SUPER-POWER LOCOMOTIVES

IN 1925, Lima Locomotive Works, Incorporated, at its own expense, built an experimental locomotive, the A-1, which embodied for the first time all of the elements of design that are now considered essential to truly modern power. • The Lima A-1 was the forerunner of the Super-Power Locomotives that have made possible the modernization of railroad operation. • By developing higher boiler horsepower per pound of weight than had ever before been attained, a new standard of locomotive performance was set. • The work of locomotive improvement goes continually forward and Lima is proud of its contributions to the art.

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LIMA LIMA LOCOMOTIVE WORKS INCORPORATED OHIO

service to freight receiving stations, airports and emergency landing fields; (d) reconstruction designed to reduce maintenance cost and decrease future state and local highway expenditures; (e) providing a large number of small projects designed to employ the maximum of human labor; and (f) the elimination of hazards to highway traffic, such as the separation of grades at crossings, the reconstruction of existing railroad grade crossing structures, the relocation of highways to eliminate railroad crossings, the widening of narrow bridges and roadways, the building of footpaths, the replacement of unsafe bridges, the construction of routes to avoid congested areas, and the construction of facilities to improve accessibility and the free flow of traffic."

Not more than 50 per cent of the funds apportioned to any state may be applied to projects on the federal-aid highways system outside of the corporate limits of municipalities; not less than 25 per cent to projects on extensions of the federal-aid highway system into and through municipalities; and not more than 25 per cent to secondary or feeder roads until provision has been made for the satisfactory completion of at least 90 per cent of the initial limiting federal-aid highway system in the state. The reconstruction of existing facilities that are adequate for traffic are not to be considered needed improvements.

The National Automobile Chamber of Commerce has taken the initiative toward bringing about a national federation of state motor truck associations to take advantage of the provisions of the industrial recovery act relating to codes as to wages, hours of employment and fair practices, and the National Association of Motor Bus Operators is considering the preparation of codes relating not only to wages and hours but also to rate tariffs, schedules and fair practices and dealing with the problems of "wildcat" competition.

Freight Car Loading

WASHINGTON, D. C.

REVENUE freight car loading continued its rapid increase in the week ended June 17, amounting to 587,931 cars, an increase of 23,385 cars as compared with the week before and of 69,533 cars as compared with the corresponding week of last year. As compared with 1931 it was a decrease of 151,163 cars but the cumulative loading to date is now less than 8 per cent behind that for the corresponding week of last year. Loading of all commodities except merchandise, l. c. l., increased as compared with the corresponding week of last year and all except merchandise and livestock increased as compared with the preceding week, while grain and grain products showed a gain as compared with 1931. The summary, as compiled by the Car Service Division of the American Railway Association, follows:

Revenue Freight Car Loading

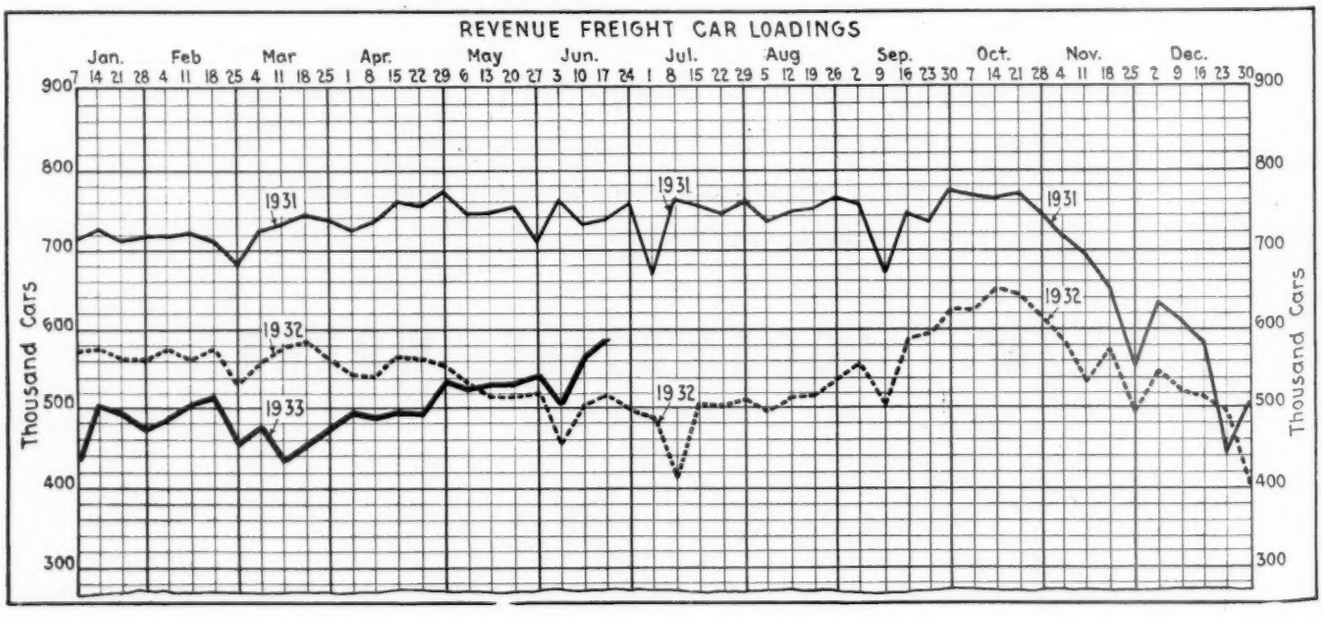
Week ended Saturday, June 17, 1933

Districts	1933	1932	1931
Eastern	135,816	118,593	162,272
Allegheny	114,490	99,407	146,440
Pocahontas	40,809	30,515	46,940
Southern	87,017	75,228	109,237
Northwestern	74,984	61,790	104,845
Central Western	82,496	83,591	107,424
Southwestern	52,319	49,274	61,936
Total Western Districts	209,799	194,655	274,205
Total All Roads	587,931	518,398	739,094
Commodities			
Grain and Grain Products	38,147	25,795	32,771
Live Stock	15,450	15,400	19,549
Coal	93,604	68,605	109,331
Coke	4,898	2,941	5,451
Forest Products	25,520	17,140	30,555
Ore	12,266	4,290	30,640
Mdse. L. C. L.	168,530	175,819	217,136
Miscellaneous	229,516	208,408	293,661
June 17	587,931	518,398	739,094
June 10	564,546	501,685	732,409
June 3	508,324	447,412	761,084
May 27	541,309	521,249	711,249
May 20	531,618	515,628	754,738
Cumulative total, 24 weeks	12,002,976	13,120,546	17,593,492

Car Loading in Canada

Car loadings in Canada for the week ended June 17 amounted to 40,571 cars. This was 253 cars fewer than for the previous week and reduced the index number from 65.63 to 64.71.

	Total Cars Loaded	Total Cars Rec'd from Connections
Total for Canada:		
June 17, 1933	40,571	19,283
June 10, 1933	40,824	18,624
June 3, 1933	38,886	17,151
June 18, 1932	44,736	18,065
Cumulative Totals for Canada:		
June 17, 1933	825,749	419,971
June 18, 1932	1,001,272	496,137
June 13, 1931	1,156,498	667,401



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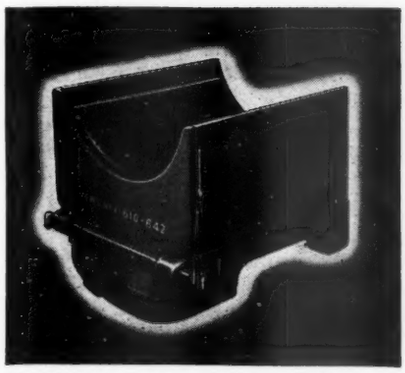
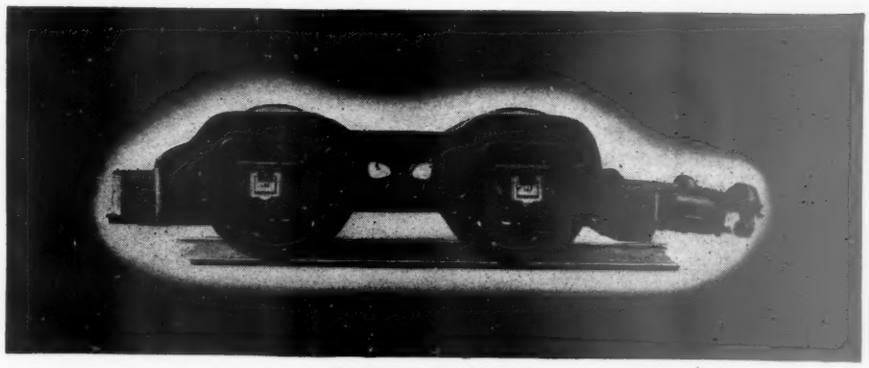
FRANKLIN'S CONTRIBUTION
To The Modern Locomotive



Franklin Driving Box Lubricator and Spreader



The Locomotive Booster

Franklin Butterfly Fire Door

THE FRANKLIN Driving Box Lubricator by providing constant lubrication, really made the modern locomotive possible. This grease cellar was the first of many outstanding locomotive improvements developed and perfected by Franklin Railway Supply Company and it has since been standardized throughout the world.

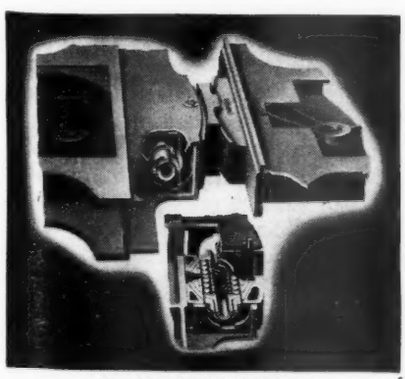
The automatic, power operated fire door was another Franklin development which made it physically possible to fire the big engine as well as save lives in the event of accident in the firebox.

The Power Reverse Gear was another Franklin device to save labor and fuel.

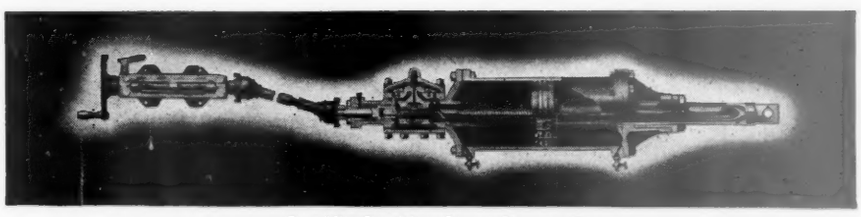
In the Radial Buffer and Unit Draw Bar, Franklin brought security to the engine and tender connection and prevented derailments, break-in-twos, and loss of life.

But the crowning achievement of Franklin has been the perfection of The Locomotive Booster. By putting idle weight and spare steam to work, the Booster has made possible a substantial advance in power per pound of locomotive weight and has contributed mightily to the economy of railroad operation.

For over a quarter of a century, Franklin has been developing new locomotive improvements designed to promote economy and safety. These have contributed largely to the present highly efficient state of modern motive power.



Franklin Radial Buffer



Franklin Precision Power Reverse Gear

FRANKLIN RAILWAY SUPPLY COMPANY, INC.

NEW YORK CHICAGO MONTREAL

Ewing Heads the Central of New Jersey

To fill the vacancy caused by the resignation of R. B. White to become president of the Western Union Telegraph Company, the directors of the Central of New Jersey have elected to the presidency of that company, Charles H. Ewing, president of the Reading. Edward T. Stotesbury, chairman of the board of the Reading, has been elected chairman of the executive committee and Daniel Willard, president of the Baltimore & Ohio, has been elected to the chairmanship of the Reading's board of directors. A photograph and an outline of Mr. Ewing's railroad career were published in the *Railway Age* of May 7, 1932, page 777, in connection with his election to the presidency of the Reading, succeeding the late Agnew T. Dice.

The Central of New Jersey is controlled by the Reading, which owns some 53 per cent of its outstanding capital stock, which, however, has by court order been held by trustees. Since the two properties are included with the Baltimore & Ohio in the four-system consolidation plan approved by the Interstate Commerce Commission for eastern territory, however, both the court and the commission have consented to the withdrawal of the stock from the trustees and the Reading now may exercise its control.

It is believed that the election of Mr. Ewing to the presidency of the two companies will result in further integration of their operations. As a matter of fact, the two companies have long worked together in the closest of harmony, with many joint services and facilities. In turn the Baltimore & Ohio, which has a large, if not literally controlling, stock interest in the Reading, uses the lines and terminals of both the Reading and Jersey Central between Philadelphia and New York. The Reading and Jersey Central are, in fact, complementary to each other. Both are closely knit properties, terminal in character, with, in addition, important lines in the anthracite fields of Northeastern Pennsylvania. The Reading converges on Philadelphia, the Jersey Central on New York.

Table I shows comparative revenues and expense figures for the two roads for 1932, compared with those for 1929. It will be seen that both properties have weathered the depression quite well—the Reading with net income for 1932 of four and one quarter millions, while the Jersey Central held its deficit to a comparatively low total. Both roads rely heavily on coal traffic, the greater proportion of which is anthracite for domestic use. This traffic, it will be noted, is far more stable than merchandise freight, although it too is subject to competition on the shorter hauls from motor trucks. The effective manner in which operating expenses were held in check on both roads will be observed. The Reading indeed had a somewhat more favorable ratio in 1932 than it did in 1929, whereas the Central of New Jersey in 1932 held this index almost to the 1929 level. Taxes paid by the two roads in 1932 make an interesting comparison. When viewed in the light of their respective gross revenue totals, the tax burden of the smaller line appears fantastically high by comparison, this being due no doubt to the tax policies of the state of New Jersey which are being contested in the courts. If the Central of New Jersey had been taxed relative to its gross revenues as the Reading was, its deficit would have been wiped out and some net income would have resulted.

Table I—Reading Central of New Jersey—Revenues and Expenses—1932 and 1929 Compared

	Reading			C. N. J.		
	1932	1929	% Inc. or Dec.	1932	1929	% Inc. or Dec.
Coal Traffic Revenues	$25,138,349	$37,485,247	−32.9	$10,778,000	$16,424,160	−34.4
Merchandise Traffic Revenues	19,439,298	45,237,747	−57.0	12,104,998	28,619,133	−57.7
Passenger Revenues	3,368,996	7,080,681	−52.4	5,066,452	8,749,393	−42.1
Total Operating Revenues	51,806,374	97,196,954	−46.7	30,357,468	58,136,939	−47.8
Maintenance of Way Expense	4,270,016	14,097,108	−69.7	2,306,481	5,796,291	−60.2
Maintenance of Equipment Expense	10,676,670	22,000,822	−51.5	5,768,362	11,955,091	−51.8
Transportation Expense	20,416,988	35,698,864	−42.8	12,030,919	21,636,350	−44.4
Total Operating Expenses	38,804,168	75,929,795	−48.9	22,182,691	42,218,295	−47.5
Net Revenue from Railway Operations	13,002,205	21,267,159	−38.9	8,174,776	15,918,643	−48.7
Operating Ratio, Per cent	74.90	78.12	−4.1	73.07	72.62	+0.6
Taxes	$1,590,520	$4,439,920	−64.2	$4,857,581	$5,074,796	−4.3
Net Railway Operating Income	11,086,616	17,196,521	−35.5	2,507,298	9,367,044	−73.2
Non-Operating Income	2,760,705	6,953,343	−60.3	1,594,104	1,587,697	+0.4
Gross Income	13,847,321	24,149,864	−42.7	4,101,402	10,954,742	−62.6
Deductions from Gross Income	9,618,532	8,641,123	+11.3	5,929,485	5,911,987	+0.3
Net Income	4,228,789	15,508,740	−72.7	*1,828,082	5,042,754	−136.3

* Deficit.

Table II—Selected Operating Statistics for 1932, Reading and Central of New Jersey Compared

	Reading	C. N. J.
Miles of Road Operated	1,462	692
Net Ton-Miles (Rev. and Non-Rev.), Thousands	3,905,761	*1,548,584
Average Net Tons per Train	840	935
Average Haul, Miles	103	74
Average Revenue per Ton-Mile, Cents	1.141	1.478
Average Freight Revenue per Mile of Road, Dollars	30,679	33,068
Average Freight Revenue per Train-Mile, Dollars	9.59	13.15
Average Passenger Train Revenue per Train-Mile, Dollars	0.88	1.58
Gross Ton-Miles per Train-Hour	22,870	26,725
Average Freight Train-Miles per Train-Hour	12.1	13.0
Per Cent Loaded to Total Car-Miles	57.7	55.7
Lb. of Coal per 1000 Gross Ton-Miles	146	141
Per Cent of Freight Cars Unserviceable	10.6	20.0
Per Cent of Freight Locomotives Unserviceable	26.4	34.0

* Revenue only.

Table II compares selected operating statistics of the two companies and shows how closely similar they are. The average haul on both roads is short, and their freight revenues per mile of line almost the same. In neither fuel performance, average train speed nor average train load is the variance great. There is some difference in one or two of the comparative figures, but these can readily be explained by some slight variance in local conditions. Properties so interwoven physically, so similar in their operating problems, and interchanging traffic to such a degree, it would appear, should thrive with a joint executive to co-ordinate their practices and operations.

In an important new field—highway transport—operations of the two companies are already closely linked. The Reading was one of the early railroads to engage in motor transportation—first for passengers and later also for freight. The Reading's motor transport subsidiary also serves the territory of the Jersey Central. At the end of 1932 the subsidiary operated 1,160 route miles of bus service and 889 miles of truck service, effecting considerable savings to the railroads in the elimination of unprofitable trains.

Another task of co-ordination in which the Jersey

Continued on next left-hand page

The Modern Locomotive Arch

is a development of

AMERICAN ARCH COMPANY

THE Security Sectional Arch has long been regarded as being as essential to the locomotive as the driving wheels.

In its present state, the locomotive Arch is the result of a quarter century of intensive research and development by American Arch Company.

Starting with heavy slabs of refractory requiring two men to handle, the Arch has been sectionalized, shapes standardized and designs perfected to give longer life and superior service.

When the introduction of the stoker brought new conditions in the firebox, American Arch Company engineers were ready with suitable Arch designs.

The Syphon, again, changed locomotive combustion and once more American Arch Company engineers revised the Arch to harmonize with the new conditions.

For years past, practically every new design of locomotives has had the Arch designed by American Arch Company.

This engineering service is one of the important elements in satisfactory Arch brick service.

American Arch Company, alone, is qualified by experience to supply it.

THERE'S MORE TO SECURITY ARCHES THAN JUST BRICK

HARBISON-WALKER REFRACTORIES CO.
Refractory Specialists

AMERICAN ARCH CO.
INCORPORATED
Locomotive Combustion Specialists

Central's new executive will participate will be that of combining the operation of the Reading's seashore subsidiary, the Atlantic City Railroad, with the Southern New Jersey lines of the Pennsylvania, which project was recently approved by the Interstate Commerce Commission.

Stimulating Tourist Travel

AN European who had traveled much on that continent and in adjacent countries, made his first trip to the United States, penetrating much further into this country than is ordinarily the case with such tourists. Unexpectedly meeting an American friend in the Southwest, he exclaimed after a few moments, "Why do so many Americans come to Europe when you have such marvelous things to see in your own country?"

Could not the American railways do much to encourage tourists from other countries by more aggressively advertising these features abroad? As an example, the Japan Tourist Bureau, closely related to the Japanese Government Railways, is making an interesting experiment in this country, which promises excellent results in stimulating tourist travel to Japan.

First it secured the co-operation of The American Boy, with which is combined The Youth's Companion. In the February number of that periodical an announcement was made that three two-months trips to Japan would be awarded for the best three essays on "Japan —And Why I Want to Go There." The requirements for the contest were quite simple. The entries had to be submitted before March 10, and the essays should preferably be under 300 words. The contestants must be under 21 years of age on the closing date of the contest. In addition to the three first prizes, the writers of the next best 12 essays were to receive Japanese silk lounging robes.

Those who entered the contest were asked to write to the Japan Tourist Bureau for literature on that country. The Bureau received 2,547 requests for such information and 1,762 essays were submitted before the closing date of the contest. The first prize was awarded to Donald G. Bradlor, 15 years old, Hollywood, Cal.; the second to K. Stromquist, 15 years of age, Birmingham, Ala.; and the third to Milton Williams, Jr., 18 years of age, Washington, Ga. The judges in the contest were Hon. K. Horinouchi, Consul General; Y. Shudo, commercial secretary to the Japanese Embassy; Y. Yamamoto, resident representative, Japanese Government Railways; K. Takahashi, manager, Nippon Yusen Kaisha; T. Toda, manager, Osaka Shosen Kaisha; T. Go, manager, South Manchuria Railway, M. Y. Inomata, Japan Tourist Bureau; Griffith Ogden Ellis, president and editor, The American Boy.

A staff writer for The American Boy, Mitchell V. Charnley, assistant professor of journalism at Iowa State College, will accompany the boys, who will sail from Seattle on June 30, returning to this country early in September. They will spend five weeks traveling in Japan and Chosen. Not more than 90 days after their return to this country they must turn in a story of at least 4,000 words, telling of their travel experiences. The prize-winning essay by Donald G. Bradlor follows:

Since Commodore Perry's visit to Japan in 1854, modern Japanese development has parelleled our American growth. Japan's influence and power in the East are comparable to our own in this hemisphere. Both countries border the Pacific and have a great many interests and many problems in common.

However, despite these similarities of interest, an unwise American immigration law, distance, and competitive naval construction have served to hinder development of a real friendly feeling between the two peoples.

It is high time that Japanese and Americans clasp hands across the sea in a genuine friendly way. Nothing can probably do more to foster future trade and amity between the two nations than an interchange of student travelers.

It would thrill me, beyond words, to pioneer such an exchange of young travelers. What adventure a trip to far distant Japan would hold for me, and other young Americans! A new world of thought and living would unfold itself before us! What interesting contacts we would make; oriental people whose religion, daily thoughts and mode of living are one hundred and eighty degrees away from our own! What vistas of beauty would appear to delight us; cherry blossoms, ancient temples and gardens, glorious mountains and sea! What great commercial possibilities would hint at us and invite thought; great cities, factories, fisheries, and undeveloped areas! We would return to the United States with an enlarged vision of world affairs and a new appreciation of the Orient.

I want to go to Japan to experience a great adventure and to see and enjoy and benefit from all of the above mentioned things. But more important, I want to see and meet Japanese boys. I want to talk to Japanese people in city and country, in industry and at home. I want to know how they live and what they think. I want to tell them how American boys live and play. Personal contact leads to better understanding, and an appreciation of the other fellow's problems. It is so with men. It must be so with nations. May more American boys visit Japan! May more Japanese boys visit the U. S. A.!

Mechanical Division Holds Limited Meeting at Chicago

(*Continued from page 59*)

ported that the investigation of automatic connectors was continued in the laboratories at Purdue University during the past year. Plans and specifications were submitted by 51 different companies or individuals, these specifications being carefully studied and nine different devices ordered for laboratory tests. These laboratory tests have now been completed and, if no additional designs are submitted, the report covering the connectors tested will be put in final form.

The Committee on Locomotive and Car Lighting held no meeting during the past year, but it has been watching developments in the air-conditioning of passenger-train cars, in view of the divergent methods and systems now being tried.

The Committee on Specifications for Materials proposed revised specifications for carbon-steel bars and springs, carbon-steel castings, lumber, hose for air, gas and oxygen, chains and elliptic springs. It recommended that a number of specifications dealing with paint materials be withdrawn from the Manual because they cover matters for each railroad to decide for itself. The lumber specifications are a revision of matter presented as information in 1930 which has been corrected to conform with changes in grading rules suggested by representatives of the lumber and railroad industries.

The Tank Car Committee considered a total of 112 dockets and applications for approval of design during the year. It recommended to the Interstate Commerce Commission that experimental trials for fusion-welded tanks of Class ICC-103C and Class ICC-103B, fabricated in accordance with the American Society of Mechanical Engineers' Code for Class I fusion-welded non-fired pressure vessels, be authorized. The committee also presented A. R. A. fundamental dome ring and cover drawings, as well as drawings for dome covers for certain specific classes of tanks.

News Department begins on third right-hand page

ELESCO

Factors

in Maintaining High Efficiencies—
Standardization, Improvement and Development
of LOCOMOTIVE EQUIPMENT

The high efficiencies maintained by American railroads make them the most efficient transportation service in the world today. This has been possible only through the constant improvement, development and standardization of equipment. In this progress which, with relation to motive power, has been particularly rapid during the past 10 years, the railroads have taken an active part by constant research, testing and study of equipment under actual service conditions. Hand in hand with the railroads, the equipment manufacturers have been working in co-ordination with the American Railway Association and the American Society of Mechanical Engineers through their many divisions.

Even though during the past three years, the purchase of new equipment has been gradually reduced to a negligible amount — improvements have gone forward. Elesco equipment and services have been continually improved and further standardized to meet demands which must come in the cause of better efficiencies. On the following pages are given results of intensive efforts within our organization and co-ordination of experience in this country and abroad . . . having as the single purpose continuous improvement of steam locomotive operation.

As a result of these efforts, this company is better prepared than ever to co-operate with the railroads in maintaining present high standards and establishing new records . . . through Elesco superheaters and Elesco feed water heating equipment.

Statement of Facts on the Following Pages . .

The

Locomotive

A Story of Progressive Development

Improvements

Elesco superheaters of today are a vast improvement structurally over the earlier superheaters, although the design remains fundamentally the same.

For many years Elesco superheater units have been formed by joining tubing by integrally machine-forged return bends. In contrast with the earlier use of cast-steel and welded return bends, the forged construction is far superior structurally and more efficient. It gives a homogeneous structure of uniform strength throughout, with increased thickness of the metal at the bend where it is most needed. Millions of these return bends are in use daily in the severest service, including leading railroads throughout the world, where Elesco superheaters are standard.

In the early years trouble was experienced from leaky unit joints, due to use of bolts not suited to the fluctuating and intense temperature conditions of the smokebox. An intensive study of this problem resulted in our development of a forged bolt of special steel, heat-treated to meet certain minimum physical requirements as to tensile strength, elastic limit and elongation, to give dependable service for the operating conditions of a superheater.

Similarly other improvements have been made. Superheater headers have been improved in design and material used. Cinder cutting of units, which became pronounced as stoker-firing became more general, led to the development of cinder shields, now furnished with all new and remanufactured units. Even minor parts like bands and supports for the units have been improved.

ELESCO

Twenty-three years ago this company was formed for the development and manufacture of the locomotive superheater. Today, practically every locomotive is equipped with an Elesco superheater. Under normal conditions, it is estimated that they save the railroads $100,000,000 a year in fuel, besides increasing the hauling capacity of locomotives. Without the locomotive superheater, the modern, high efficiency locomotives of today would not be possible.

Likewise, without continuous standardization, improvement and development, the locomotive superheater could not help the railroads, as it does today, in their efforts to get more power and better fuel economy. Locomotive operating conditions are now much more severe. Locomotives have been improved to meet these changed conditions and Elesco superheaters have kept abreast with the requirements.

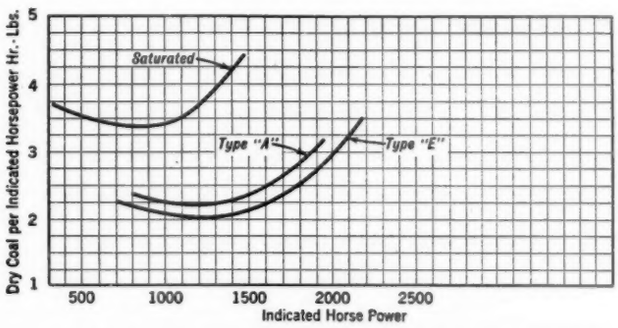
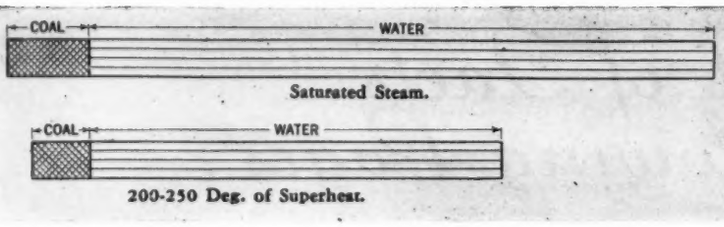


Fig. 1. Comparison of Coal Consumption of Saturated Steam Locomotives and Locomotives Equipped with Type "A" and Type "E" Superheaters.

The extent to which Elesco type "E" superheaters increase locomotive capacity and improve the fuel rate is shown by the above curves. Briefly the improvement factors of design and operation are as follows:

(1) An increase of 25 per cent in the sustained horsepower capacity, as shown on Fig. 2. This is accomplished by:
(a) Increased TRUE boiler efficiency of 5 to 7 per cent.



Superheated Steam Saves Fuel and Water, for the Same Output of Power.

e Superheater

Modern locomotives handle more tonnage at higher speeds and with marked fuel economy. Such improvement required an improved boiler design, and an improved superheater to fit. This led to development of the Elesco type "E" superheater, which, by its improved unit arrangement, gives higher superheats, increased capacity, greater efficiency . . . thereby making possible locomotives which will develop more drawbar horsepower with reduced unit fuel consumption, within the limits of weights and road clearances.

In this and in many other ways Elesco superheaters have kept pace with increasingly difficult requirements — that American railroads might always have the best and most efficient means of superheating steam.

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Curve	Class Engine	Cyl.	Tractive Power	Boiler Pressure	Wt. on Drivers	Diam. Drivers	Maximum Db.-Hp.	Type Engine	Superheater
1 & 1-A	L1 a	28"x28"	54 100#	200#	247 000#	69"	2710	4-8-2	A
2 & 2-A	L2	27"x30"	60 525#	225#	242 000#	69"	3320	4-8-2	E

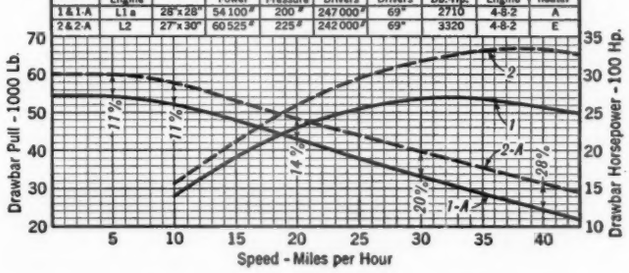

Fig. 2. Comparison of Capacities of High-speed Passenger Locomotives Equipped with Type "A" and Type "E" Superheaters.

(b) Increased evaporating surface of 6 to 8 per cent.

(c) Increased superheating surface of as much as 85 per cent, thereby increasing superheat 75 to 100 deg. F., which results in decreased steam consumption of the cylinders of 7 to 10 per cent.

(2) An increase in steam area through the superheater of as high as 30 per cent, reduces the pressure drop between boiler and cylinders, thereby giving added cylinder power.

Elesco Unit Remanufacturing Service

Supplementing the manufacture of locomotive superheaters this company, several years ago, established the Elesco unit remanufacturing service for rebuilding superheaters that have become unserviceable through years of severe operation. This service should not be confused with repairing —since it rebuilds or remanufactures superheater units — as can be done only with special and extensive equipment operated by men long experienced in this work. It is the only method by which this vital equipment is definitely restored and given renewed life for many years of trouble-free service at full capacity and full efficiency.

Multiple-valve Throttle-headers

An outstanding recent development is the improved header, having the American multiple throttle contained in the forward part of the casting. This combination of throttle and header as a single unit, follows the same general lines as the standard header, and offers many advantages, without changing the smokebox arrangement. It controls the steam between the superheater and the cylinders, and by the consecutive opening and closing of a series of small valves, the steam supply to the cylinders is finely graduated. This results in a snappier engine; one that responds promptly and in which slipping is quickly controlled. This arrangement makes superheated steam available for auxiliaries at all times and also affords protection of the superheater units.

These and many other advantages of the multiple-valve throttle-header have led to its rapid adoption for every class of locomotive service in this country and abroad.

ELESCO

Superheated Steam Increases Hauling Capacity of Locomotives, for the Same Fuel Consumption.

Saturated Steam Locomotives—Eight Cars.

Superheated Steam Locomotives—(200-250 Deg. Superheat)—Eleven Cars.

ELESCO

Reclaiming the Heat in *Waste* Exhaust Steam

Another Development for Increasing Capacity — and Further Fuel Economy

Following in the wake of the superheater, which was so quickly recognized and generally adopted, came developments of equipment suited to reclaiming heat in exhaust steam that otherwise is lost to the atmosphere. As a result of this research and development, the Elesco feed water heater was produced to reclaim this heat and return it to the boiler, through the medium of the feed water. This process of reclaiming waste heat is as sound in principle as that of superheating steam, and is a logical step in the development of more efficient locomotives. By the use of Elesco feed water heaters and Elesco exhaust steam injectors, this process effects substantial savings in fuel and water, or, for the same fuel consumption, definitely increases the sustained boiler capacity. Today it is unusual for a locomotive to be built without some form of exhaust-steam feed water heating equipment.

In order to produce types of equipment best suited by design and construction to the exacting requirements of American railroad operation, this company has studied every factor, every type, both in this country and abroad. Elesco feed water heating equipment, as a result, incorporates the practicality, simplicity and ruggedness of design so necessary for reliability and high efficiency . . . the product of many years of close association with railroad practices and sound engineering principles.

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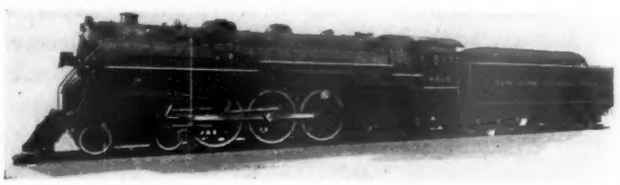
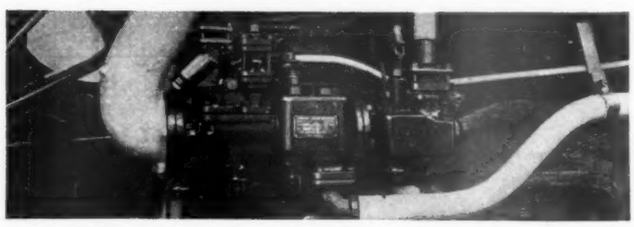


The Elesco feed water heater, which includes a heater and a pump, is based on the type of exhaust-steam feed water heating equipment, of which many thousands are in operation on railroads abroad. It makes possible increased sustained boiler capacity of approximately 15 per cent, or a fuel and water saving of 12 to 15 per cent.



The Elesco exhaust-steam injector is an injector-type of feed water heater, operating in the same manner as a live-steam injector. It is an adaptation of the Davies and Metcalfe exhaust-steam injector principle with a simplified method of control, developed especially for American railroad practice. Fuel savings of approximately 8 to 10 per cent are obtainable or an increased boiler capacity with the same fuel consumption of 12 to 15 per cent. Water savings of 8 to 12 per cent are obtained.

NEW YORK **THE SUPERHEATER COMPANY** CHICAGO

Representative of AMERICAN THROTTLE COMPANY, INC.

Canada: THE SUPERHEATER COMPANY, LTD., Montreal

Superheaters — Feed Water Heaters — Exhaust Steam Injectors — Superheated Steam Pyrometers — American Throttles

A-716

NEWS

Stealing of Train Rides Becomes More Prevalent

Over 300,000 boys, in addition to thousands of men, found to be "hitch-hiking"

Over 300,000 boys between the ages of 12 years and 20 years, in addition to many thousands of men, are "hitch-hiking" and stealing rides on freight and passenger trains. In one town in the West, 35 young men became ill while riding in box cars and were turned over to a city for medical attention. In Kansas City, Mo., an average of 1,500 men and boys a day rode freight trains out of that city. In Yuma, Ariz., 30,000 men and boys were fed at public soup kitchens between November 1 and March 15. At El Paso, Tex., 20,059 boys under the age of 21 were fed during the months of April and May. At Los Angeles, Cal., 623 men and boys from 45 states were given shelter in a period of five months. At North LaCrosse, Wis., on June 10, eight hobos were taken off the head end of one passenger train.

These figures indicate the magnitude of this great volume of illegitimate travel. The irony of the situation is reflected in the increasing number of men who are employed to drive automobiles from factories to dealers and who on returning to the factory steal rides on freight and passenger trains. On June 3, two men were taken from the head end of a passenger train at Savanna, Ill., and investigation developed that these men were employees of an automobile convoy service company and were returning to Chicago from a trip to Lancaster, Wis., where they had delivered two automobiles. They had in their possession two checks, one in the amount of $423.06 and the other for $704.20, payable to an automobile manufacturing company, in addition to $13 in cash.

The persons stealing rides include men and women and also children of all ages. At Keokuk, Iowa, on June 1, two children, 6 and 8 years old, were discovered in a box car enroute from Hamilton, Ill., to their mother in Hannibal, Mo. In April, a man and a woman about 70 years old boarded a freight train at Kansas City, Mo., with the purpose of reaching a city in Nebraska. An engineman took compassion on the couple, who were carrying six suitcases, and offered to place their luggage in his locker, but the suitcases were stolen from the locker and now the couple expect the railroad to stand the loss.

Another annoying development among "train riders" is the robbing of hobos by hobos. At Zeigler Junction, Ill., in May, three hobos introduced the practice of robbing hobos, returning from southern strawberry fields, of money and clothes. The railroad, feeling that if these men were permitted to continue this practice they would become bolder and hold up train crews and rob merchandise cars, called the matter to the attention of the county sheriff, who arrested the men.

Effective Date of Power Reverse Gear Order Postponed

The Interstate Commerce Commission has issued an order postponing the effective date of its order of January 3, requiring the installation of power reverse gear on locomotives, for 30 days after the entry of an order by the federal district court for the northern district of Ohio in the proceedings in which the railroads have sought to have the order enjoined. The postponement was made at the request of the court after the commission had denied a petition of the railroads.

M. P. Prepared for Wheat Movement

The Missouri Pacific, in preparation for the movement of wheat from Kansas, Missouri, Oklahoma, Colorado and Nebraska, has accumulated 1,500 box cars in the wheat belt and will increase this to approximately 3,000 by July 1. Since January 1, the Missouri Pacific has purchased 3,810,000 ft. of lumber for construction of 152,400 grain doors, and also has made heavy purchases of lumber for repairing cars. Approximately 100 men have been added to the shop forces, principally for the preparation of cars for wheat loading, at Wichita, Kan., Ft. Scott, Osawatomie, Hoisington, Atchison, Downs, and Omaha, Neb.

Northern Pacific Excursions

Nearly 2,500 persons in 39 coaches were carried by the Northern Pacific in a two-special-trains excursion conducted under the auspices of the Greater North Dakota Association on June 4. The excursion was run from Fargo, N. D., to Medora, a distance of 347 miles, at the rate of $3 for the round trip. At Medora, the excursionists were entertained by a rodeo and other features.

The Northern Pacific has announced for June 17 its first excursion to the Century of Progress Exposition at Chicago. The train will start from Jamestown, N. D., and excursionists will remain in Chicago for three days, June 18-19-20. Approximately 500 persons are expected to participate in this special one-cent-a-mile coach excursion which has for its objective Lutheran Day, Swedish Day and Norwegian Day, which will be celebrated at the Fair on the respective dates.

Copeland Sees No U.S. Gain from St. Lawrence Seaway

Senator assails project in address before Women's Traffic Club of Greater New York

Declaring that it is absurd to think that the St. Lawrence Seaway would profit the Great Lake ports or the western population of the United States, Senator Royal S. Copeland of New York, in an address delivered on June 24, pointed out why he thinks that "We can ill afford to jump at this proposal as if it were so remarkably desirable." The address was delivered at the second anniversary dinner of the Women's Traffic Club of Greater New York at which Mrs. Jo Schifferdecker, president of the club, presided.

Speaking, as he was, before a New York audience Senator Copeland called upon them to consider "whether or not our state can afford to meet the terrifying cost of the completed project." He presented figures to show that the total cost of the St. Lawrence development is variously estimated at from $543,000,000 to $1,350,000,000 and thus the cost to the United States would be from $300,000,000 to at least twice that sum. Of this latter New York taxpayers would be called upon to pay 30 per cent or from $90,000,000 to $180,000,000. This latter, along with the $90,000,000 to be charged directly against New York for power development, the Senator calculated, would leave New York paying from $180,000,000 to $270,000,000. "Where would we get it?" he asked.

Abstracts from other sections of the address follow:

"Regarding this project, there are two schools of thought. The St. Lawrence route is held in high favor in the West. But many thinking Americans feel that if the money of the nation is actually to be expended in canal building, it should be spent wholly within the borders of our country. They are those who advocate what is known as the 'All-American Route' a canal connecting the Great Lakes with the headwaters of the Hudson river.

"Unfortunately, whichever way is determined upon, the most we can expect of such a canal is that it shall be serviceable for not to exceed eight months of the year. In fifty years, the latest the St. Lawrence was open for navigation was December 14. Three times only was it open past December 8. Usually it closes about November 20.

"During the same period, the earliest date it ever opened was March 29. One year it opened on April 3. Unusually it opens about April 20 and occasionally as

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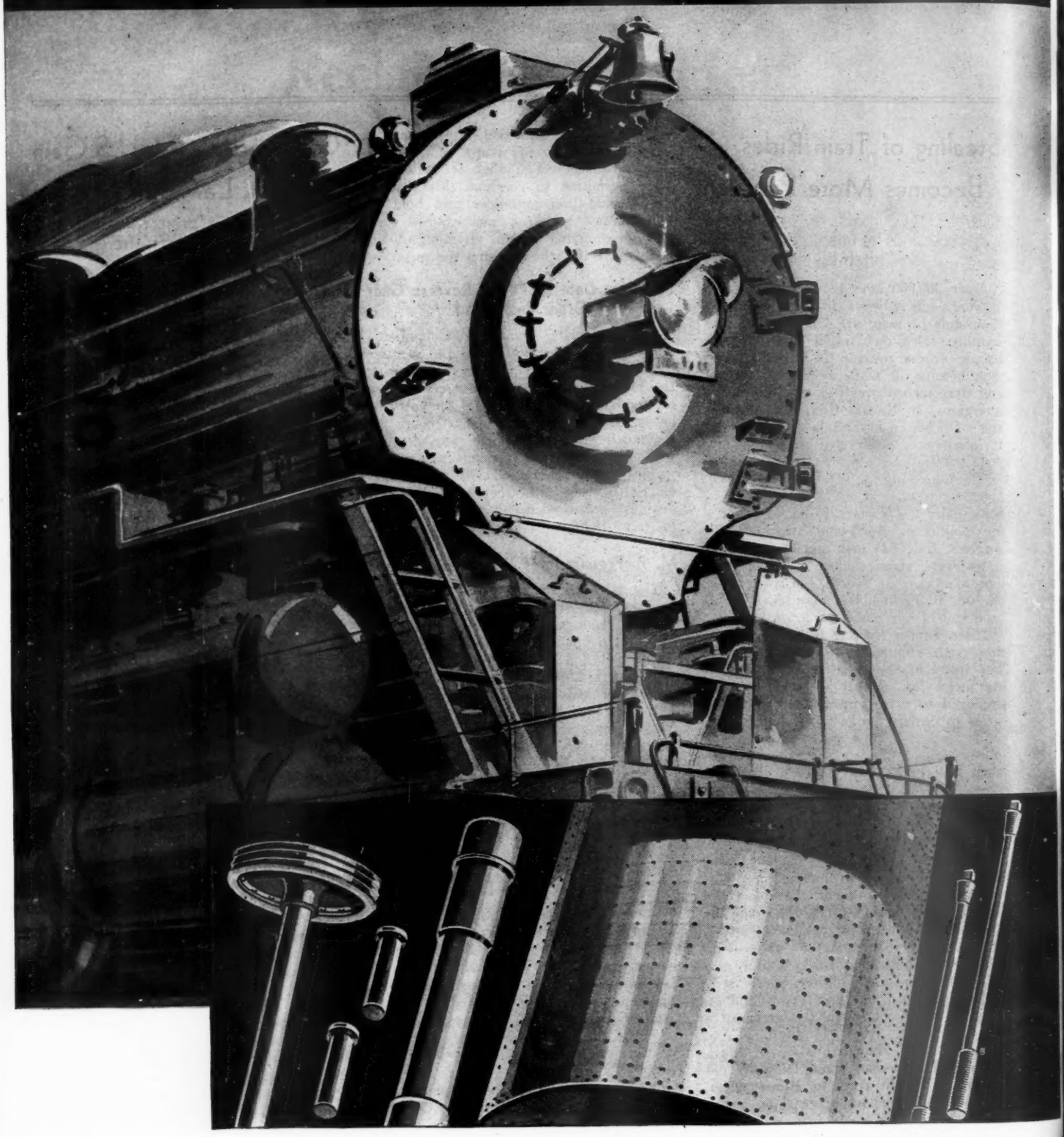
SPECIAL REPUBLIC STEELS



ARE MEETING THE DEMAND FOR BETTER MATERIALS

Locomotive designers have stepped up horsepower until 1,000 H. P. per axle is not uncommon. At the same time, weight has been kept down so that power output per pound of weight has increased. » Working closely with these designers have been the metallurgists of Republic Steel Corporation, applying alloy steels to new problems of stress. » Alloy steel piston rods, pins, axles, firebox sheets, staybolts, motion work and other vital parts can meet the increased strain of increased power because they are modern alloy materials—many of them developed specially by Republic for railroad work. » Where you have a materials problem involving iron or steel, consult Republic.

Toncan Iron Boiler Tubes, Pipe, Plates, Culverts, Rivets, Staybolts, Tender Plates and Firebox Sheets • Sheets and Strip for special railroad purposes • Agathon Alloy Steels for Locomotive Parts • Agathon Engine Bolt Steel • Agathon Iron for pins and bushings • Agathon Staybolt Iron • Climax Steel Staybolts • Upson Bolts and Nuts • Track Material, Maney Guard Rail Assemblies • Enduro Stainless Steel for dining car equipment, for refrigeration cars and for firebox sheets • Agathon Nickel Forging Steel.

The Birdsboro Steel Foundry & Machine Company of Birdsboro, Pa., has manufactured and is prepared to supply, under license, Toncan Copper Molybdenum Iron castings for locomotives.

CENTRAL ALLOY DIVISION, MASSILLON, OHIO

AGATHON STEELS

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GENERAL OFFICES — YOUNGSTOWN, OHIO

TONCAN IRON

late as the first of May. One year it was May 7. As a matter of fact, then, the St. Lawrence can be depended on for only a little more than seven months of the year.

"No candid person, conversant with the physical conditions of the lower St. Lawrence and of that route to the sea, can fail to acknowledge that through a majority of the months of the year there is not uninterrupted passage between Montreal and the open ocean.

"One has but to study the Montreal traffic situation to see how valueless the St. Lawrence is to the American merchant receiving goods from the East. In 1925, of the lake carriers arriving in Montreal with grain, coal and flour, no less than 2,670 returned westward without cargoes. There was absolutely nothing for them to take West. These are the official figures obtained from the Lachine Canal office, Montreal, April, 1926. There need be no expectation of better conditions as a result of deepening and widening canals already in existence.

"To my mind, it is absurd to think the St. Lawrence route would profit the Great Lake ports, or the great western population of our country. A one-way water system could never pay, and this route could never be anything but a one-way system. What is produced in Europe that the midwest wants in ship-cargo lots? Regardless of the doubtful advantages to the decreasing exportation of wheat, what else is there to expect from a through line to Europe, entering the sea a thousand miles from our own eastern and southern Atlantic seaboard?"

Recapture Proceedings Discontinued

The Interstate Commerce Commission has issued orders cancelling the various hearings which had been set in recapture cases, following the repeal of the recapture clause of the interstate commerce act by the emergency transportation act of 1933.

Maintenance of Way and Structures Expenses—Correction

Statistics of operating revenues and expenses of Class I steam railways in the United States, as compiled by the Bureau of Statistics, Interstate Commerce Commission, show that for the four months ended with April, 1933 and 1932, the maintenance of way and structures expenses were as follows: United States, $91,365,372 for 1933 and $121,847,150 for 1932; Eastern District, $36,189,819 for 1933 and $52,635,647 for 1932; Southern District, $19,626,148 for 1933 and $25,328,-370 for 1932; Western District, $35,549,-405 for 1933 and $43,883,133 for 1932. Because of a printer's mistake, erroneous figures were substituted where the first four of the foregoing should have appeared in the table published on page 914 of the *Railway Age* of June 24.

New D. L. & W.—D. & M. M. Connection Dedicated

Appropriate ceremonies on June 8 marked the dedication of the new switch connection between the Delaware, Lackawanna & Western and the Dansville & Mount Morris, near Groveland, N. Y. Since new connection will afford a more direct route to and from Dansville, N. Y., the dedicatory ceremonies were arranged jointly by E. M. Harter, president and general manager of the Dansville & Mount Morris, and P. E. Blum, chairman of the manufacturers' committee of the Dansville Board of Trade. Mr. Harter in his address spoke of the problems attending the rise of subsidized highway transport and warned his audience that, "If you quit using the railroads you will sooner or later quit using railroad taxes." Other speakers were Mr. Blum and representatives of the D. L. & W.

I. C. C. Approves Pooling of Passenger Service

The Interstate Commerce Commission, Division 6, on June 19 approved two examples of railroad co-ordination initiated before the new legislation on that subject was passed. It approved a supplemental contract between the Great Northern, the Northern Pacific and the Oregon-Washington to provide for operation of three pooled passenger trains each way daily in lieu of five now operated between Seattle, Wash., and Portland, Ore., and for a division of the earnings. It also approved a contract between the Chicago & North Western and the Chicago, St. Paul, Minneapolis & Omaha and the Minneapolis, St. Paul & Sault Ste. Marie and the Wisconsin Central providing for a pooling of passenger train revenues and service between Duluth, Minn., Superior, Wis., and lake region points and Chicago and Milwaukee.

Short Lines Draw Plans for Co-ordination

A resolution, pledging the co-operation of the country's short line railroads with the government under the new co-ordinator legislation and providing for representation on the three national committees, was adopted at the annual meeting of the American Short Line Railroad Association at Chicago on June 23-24. Under the proposed plan, the short line railways will elect committees of five in each of the three established regional zones. These committees will select one of their number to serve on the three national regional committees embracing all the railroads. This plan will be submitted to Joseph B. Eastman, federal co-ordinator. W. L. White, vice-president and general manager of the Yosemite Valley, was elected president of the association to succeed Bird M. Robinson, who died on June 16. Vice-presidents elected include M. T. McKee and John A. Streyer.

Canadian Roads Propose Further Wage Reductions

The Railway Association of Canada announced in Montreal last week that it had served notice upon the officers of the Brotherhood of Maintenance of Way Employees and the Railway Employees' Department of the American Federation of Labor that a further downward revision of wages has become necessary.

In the case of both organizations the wage revision follows the plan that was recently endorsed by the Board of Conciliation in the case of trainmen, enginemen and telegraphers. It maintains the basic rates as agreed upon between the railroads and the organizations but calls for the continuation of a ten per cent deduction now in force and a further deduction of ten per cent, making a total deduction of twenty per cent from wages calculated at the basic rates. The railways' proposal is that the additional ten per cent deduction go into effect July 15 in the case of the Federated Trades organization.

Rate Case Before Commission for Decision

The Interstate Commerce Commission devoted two and a half days this week, June 26, 27, and 28, to hearing arguments in No. 26,000, the proceeding in which, at the request of several large organizations of shippers and state commissions, it has been conducting an investigation as to whether it should order general reductions in freight rates at a time when most of the railroads are still earning deficits and they have agreed at the request of the administration to propose no further reductions in wages for a year and when other branches of the federal government are trying to promote increases in wages, prices, and employment. Arguments for the railroads were presented by R. V. Fletcher, general counsel of the Association of Railway Executives; J. R. Bell, commerce counsel of the Southern Pacific; W. A. Northcutt, general solicitor of the Louisville & Nashville; and W. S. Jenney, vice-president and general counsel of the Delaware, Lackawanna & Western.

Fuel Association Elects Officers

At a meeting in Chicago on June 16, called for the purpose of electing officers, the International Railway Fuel Association elected the following for 1933-1934: President, J. M. Nicholson, master mechanic of the Atchison, Topeka & Santa Fe., Slaton, Tex.; vice-presidents, W. G. Black, vice-president of the Chesapeake & Ohio, Cleveland, Ohio; C. I. Evans, chief fuel supervisor of the Missouri-Kansas-Texas, Parsons, Kan.; and L. P. Michael, chief mechanical engineer of the Chicago & North Western, Chicago; and secretary-treasurer, T. Duff Smith, Chicago.

The Executive committee elected consists of: C. H. Dyson, fuel agent of the Baltimore & Ohio, Baltimore, Md.; T. C. Hudson, general superintendent of the Canadian National, Toronto, Ont.; W. J. Tapp, fuel supervisor of the Denver & Rio Grande Western, Denver, Colo.; J. D. Clark, chief fuel supervisor of the Chesapeake & Ohio, Richmond, Va.; L. E. Dix, fuel supervisor of the Texas & Pacific, Dallas, Tex.; C. Roberts, assistant road foreman of engines of the Pennsylvania, Philadelphia, Pa.; C. T. Winkless, fuel engineer of the Chicago, Burlington & Quincy, Chicago; J. G. Crawford, fuel engineer of the Chicago, Burlington & Quincy, Chicago; J. R. Jackson, engineer of tests of the Missouri Pacific, St. Louis, Mo.; G. Likert, fuel engineer of the Union Pacific, Omaha, Neb.; and W. J. Overmire, fuel engineer of the Cleveland, Cincinnati, Chicago & St. Louis, Indianapolis, Ind.

The Advisory committee elected consists

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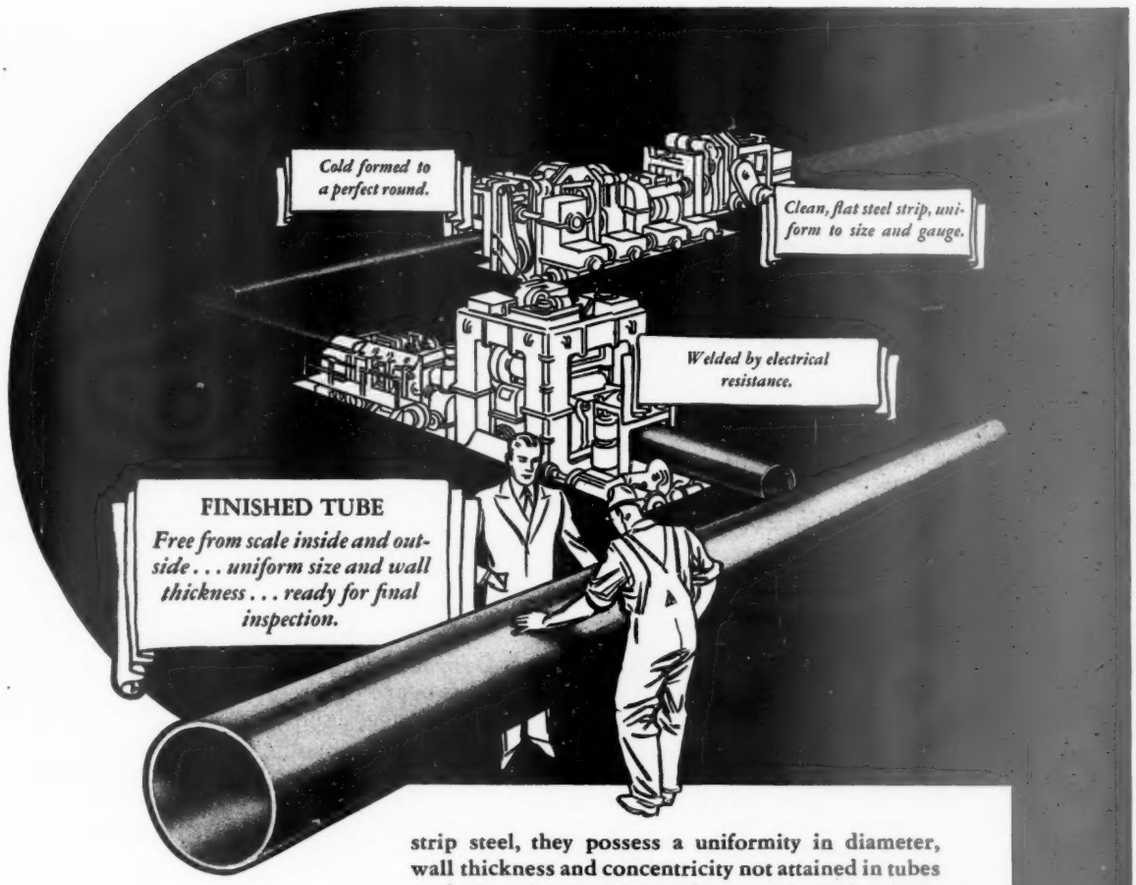
An Important Message . . .
TO EVERY USER OF BOILER TUBES


Cold formed to a perfect round.
Clean, flat steel strip, uniform to size and gauge.
Welded by electrical resistance.
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Free from scale inside and outside . . . uniform size and wall thickness . . . ready for final inspection.

AFTER many years devoted to the manufacture of tubing by the electrical resistance welding method, during which more than a billion feet of tubing was made for countless purposes, Steel and Tubes, Inc., Cleveland, decided to apply the experience so gained to the production of a better boiler tube made by this same process.

The first Electrunite Boiler Tubes were placed in service early in 1932. Since then they have met an enthusiastic welcome wherever they have been used. Some of the largest railroads have been quick to appreciate their superiority and have already placed them on their approved lists.

Because Electrunite Boiler Tubes are made from strip steel, they possess a uniformity in diameter, wall thickness and concentricity not attained in tubes made by other processes. Due to the mechanically controlled electrical resistance method employed in welding, the weld is as strong as the wall. Tubes are full-normalized, soft, ductile and of uniform grain structure. Every tube is tested at pressures far in excess of code requirements. Electrunite Boiler Tubes, because of these qualities, make possible tighter joints with worth-while savings in time and labor. Users report savings of 15 to 20 per cent in installation costs.

The entire research and metallurgical facilities of Republic Steel Corporation and Steel and Tubes, Inc., stand back of the development of these better boiler tubes. Further particulars will gladly be sent upon request. Write today.

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World's Largest Producer of Electrically Welded Tubing
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of: P. E. Bast, fuel engineer of the Delaware & Hudson, Albany, N. Y.; E. E. Chapman, engineer of tests of the Atchison, Topeka & Santa Fe, Topeka, Kan.; J. N. Clark of the Southern Pacific, San Francisco, Cal.; R. Collett, fuel agent of the St. Louis-San Francisco, St. Louis, Mo.; M. A. Daly, chief fuel supervisor of the Northern Pacific, Seattle, Wash.; J. E. Davenport, assistant to vice-president of the New York Central, New York; J. B. Hurley, general road foreman of engines and fuel service of the Wabash, Decatur, Ill.; and T. Duff Smith of Chicago.

Freight Traffic in April

Freight traffic moved by the Class I railroads in the first four months of 1933 amounted to 78,286,457,000 net ton-miles, according to reports compiled by the Bureau of Railway Economics. This was a reduction of 11,129,875,000 net ton-miles, or 12.4 per cent, under the corresponding period in 1932, and a reduction of 37,788,091,000 net ton-miles, or 32.6 per cent, under the same period in 1931. The Eastern district reports for the four months reported a reduction of 12.5 per cent compared with the same period in 1932; the Southern district a reduction of 8.2 per cent, and the Western one of 13.9 per cent.

The total freight traffic in April was 19,831,280,000 net ton-miles, a reduction of 1,427,819,000 net ton-miles or 6.7 per cent under the same month in 1932, and 8,880,203,000 net ton-miles or 30.9 per cent under April, 1931. The Eastern district, record for April shows a reduction of 11.9 per cent compared with the same month in 1932; the Southern district an increase of one-tenth of one per cent, and the Western a reduction of 1.2 per cent.

N. & W. Holiday Fares

Reduced round-trip fares to New York, Philadelphia, Pa., Baltimore, Md., and Atlantic City, N. J., rates of one cent per mile between most Norfolk & Western stations and to all stations on other lines in the southeast; 16-day vacation trips to the Virginia seashore, and other travel inducements, are being offered by the Norfolk & Western for the July 4 holidays.

Low round-trip fares from stations in West Virginia (Williamson and east thereof), Virginia and North Carolina to New York, Philadelphia, Baltimore and Atlantic City, will be sold on July 1, 2 and 3, and will have a return limit of July 8. Tickets at the rate of one cent per mile will be sold also on July 1, 2 and 3 from Williamson, W. Va., and stations east thereof to destinations on other lines in the southeast. These fares will have a return limit of July 8. In this connection, it was announced that Pullman rates will be reduced 25 per cent.

Special round-trip 16-day vacation fares to Norfolk and the Virginia seashore, will go on sale July 1. The tickets—stop-overs permitted on both the going and returning trips—will provide for a free side-trip to Richmond, Va. Other holiday rates include week-end fares between all stations on the railroad and to and from other lines within the southeast; 30-day summer excursion rates each Saturday to destinations in Illinois, Indiana, Kentucky, Michigan, Missouri, Ohio and Pennsylvania; and fares at a reduction of 15 to 40 per cent of the regular rates, to all principal resorts throughout the United States and Canada. The latter will have a return limit of October 31.

New York-Chicago Trains Made Faster

New York Central and the Pennsylvania Summer train schedules, which became effective June 25, show that a number of through trains have been accelerated. The Pittsburgher of the Pennsylvania will have sleeping cars, to be transferred to the Progress Limited at Pittsburgh, making the trip through from New York to Chicago in 19 hrs., 30 min. The Rainbow, leaving New York at 11 p. m. will arrive in Chicago at 5:30 p. m., two hours earlier than formerly. The Golden Arrow in both directions will run through in 20 hrs., 10 min., about a half hour less than heretofore.

The Commodore Vanderbilt of the New York Central will run through in 20 hrs., 10 min., or about a half hour less than heretofore. The Iroquois is operated in two sections reaching Chicago by the Michigan Central at 5:30 p. m., two hours faster than heretofore; and the service over the New York Central, arriving at LaSalle street, Chicago, at 7:30 p. m., is continued. The Fast mail, eastbound, will have sleeping cars from Chicago to New York, and arrival at destination is scheduled for 6:40 a. m., with a view to giving transatlantic passengers additional time to reach the steamers.

Co-ordinator Designates Three Regional Groups

The first official act to be announced by Joseph B. Eastman as federal co-ordinator of transportation was an order made public on June 22 dividing the railroads into eastern, southern, and western groups for the purpose of the appointment of the three regional co-ordinating committees to be selected by the railroads. The list included Class I, II, and III steam railroads, switching and terminal companies, and electric railroads. The assignment of the roads to the three groups was in accordance with the usual practice in grouping reports to the commission for statistical purposes, but several roads were placed part in one group and part in another. The Illinois Central north of Cairo, Ill., was placed in the western group, while the line south of Cairo, including the Yazoo & Mississippi Valley, was placed in the southern group. The St. Louis-San Francisco east of the Mississippi river was placed in the southern group while the lines west of the river were placed in the western group. The Wabash, west of Danville, Ill., and Chicago, Ill., and south thereof was placed in the western group and the lines east thereof were placed in the eastern group.

Meetings & Conventions

The following list gives names of secretaries, date of next or regular meetings and places of meetings.

AIR BRAKE ASSOCIATION.—T. L. Burton, Room 2205, 150 Broadway, New York City.

ALLIED RAILWAY SUPPLY ASSOCIATION.—F. W. Venton, Crane Company, 836 S. Michigan Ave., Chicago. To meet with Air Brake Association, Car Department Officers' Association, International Railroad Master Blacksmiths' Association, International Railway Fuel Association, International Railway General Foremen's Association, Master Boiler Makers' Association and the Traveling Engineers' Association.

AMERICAN ASSOCIATION OF FREIGHT TRAFFIC OFFICERS.—W. R. Curtis, F. T. R., M. & O. R. R., Chicago, Ill.

AMERICAN ASSOCIATION OF GENERAL BAGGAGE AGENTS.—E. L. Duncan, 332 S. Michigan Ave., Chicago.

AMERICAN ASSOCIATION OF PASSENGER TRAFFIC OFFICERS.—W. C. Hope, C. R. R. of N. J., 143 Liberty St., New York.

AMERICAN ASSOCIATION OF RAILROAD SUPERINTENDENTS.—F. O. Whiteman, Union Station, St. Louis, Mo.

AMERICAN ASSOCIATION OF RAILWAY ADVERTISING AGENTS.—E. A. Abbott, Poole Bros., Inc., 85 W. Harrison St., Chicago. Next meeting, January 20, 1934.

AMERICAN ASSOCIATION OF SUPERINTENDENTS OF DINING CARS.—F. R. Borger, C. I. & L. Ry., 836 Federal St., Chicago. Annual meeting, October, 1933, Chicago, Ill.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—(See American Transit Association.).

AMERICAN RAILWAY ASSOCIATION.—H. J. Forster, 30 Vesey St., New York, N. Y.

- Division I.—Operating.—J. C. Caviston, 30 Vesey St., New York.
  - Freight Station Section.—R. O. Wells, Freight Agent, Illinois Central Railroad, Chicago.
  - Medical and Surgical Section.—J. C. Caviston, 30 Vesey St., New York.
  - Protective Section.—J. C. Caviston, 30 Vesey St., New York. Annual meeting, July 12-13, 1933, Hotel Stevens, Chicago, Ill.
  - Safety Section.—J. C. Caviston, 30 Vesey St., New York. Annual meeting, October 3-5, 1933, Hotel Stevens, Chicago, Ill.
  - Telegraph and Telephone Section.—W. A. Fairbanks, 30 Vesey St., New York.
- Division II.—Transportation.—G. W. Covert, 59 East Van Buren St., Chicago.
- Division III.—Traffic.—J. Gottschalk, 143 Liberty St., New York.
- Division IV.—Engineering.—E. H. Fritch, 59 East Van Buren St., Chicago. Annual meeting, March 13-15, 1934, Chicago, Ill. Exhibit by National Railway Appliances Association.
  - Construction and Maintenance Section.—E. H. Fritch, 59 East Van Buren St., Chicago.
  - Electrical Section.—E. H. Fritch, 59 East Van Buren St., Chicago.
  - Signal Section.—R. H. C. Balliet, 30 Vesey St., New York.
- Division V.—Mechanical.—V. R. Hawthorne, 59 East Van Buren St., Chicago.
  - Equipment Painting Section. — V. R. Hawthorne, 59 East Van Buren St., Chicago.
- Division VI.—Purchases and Stores.—W. J. Farrell, 30 Vesey St., New York.
- Division VII.—Freight Claims.—Lewis Pilcher, 59 East Van Buren St., Chicago.
- Division VIII.—Motor Transport.—George M. Campbell, 30 Vesey St., New York.
- Car Service Division.—C. A. Buch, 17th and H Sts., N. W., Washington, D. C.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.—C. A. Lichty, C. & N. W. Ry. 319 N. Waller Ave., Chicago.

AMERICAN RAILWAY DEVELOPMENT ASSOCIATION.—J. A. Senter, Ind., Agt., N. C. & St. L. Ry., Nashville, Tenn.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.—Works in co-operation with the American Railway Association. Division IV.—E. H. Fritch, 59 East Van Buren St., Chicago, Ill. Annual meeting, March 13-15, 1934, Chicago, Ill. Exhibit by National Railway Appliances Association.

AMERICAN RAILWAY MAGAZINE EDITOR'S ASSOCIATION.—Miss E. Kramer, M-K-T Employees Magazine, St. Louis, Mo.

AMERICAN RAILWAY TOOL FOREMEN'S ASSOCIATION.—G. G. Macina, C., M., St. P. & P. R. R, 11402 Calumet Ave., Chicago. Exhibit by Tool Foremen Suppliers' Association.

AMERICAN SHORT LINE RAILROAD ASSOCIATION.—R. E. Schindler, Union Trust Bldg., Washington, D. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Calvin W. Rice, 29 W. 39th St., New York. Railroad Division. Marion B. Richardson, Ahrens & Richardson, 30 Church St., New York.

AMERICAN TRANSIT ASSOCIATION.—Guy C. Hecker, 292 Madison Ave., New York. Annual meeting, September 18-20, 1933, Hotel Stevens, Chicago, Ill.

AMERICAN WOOD PRESERVERS' ASSOCIATION.—H. L. Dawson, 1104 Chandler Building, Washington, D. C. Annual meeting, January 24-26, 1934, Houston, Tex.

ASSOCIATION OF RAILWAY CLAIM AGENTS.—H. D. Morris, District Claim Agent, Northern Pacific Ry., St. Paul, Minn.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.—Jos. A. Andreucetti, C. & N. W., Room 411, C. & N. W. Station, Chicago. Exhibit by Railway Electrical Supply Manufacturers' Association.

ASSOCIATION OF RAILWAY EXECUTIVES.—Stanley J. Strong, Transportation Building, Washington, D. C.

BRIDGE AND BUILDING SUPPLY MEN'S ASSOCIATION.—S. A. Baber, High Grade Manufacturing Co., 10418 St. Clair Ave., Cleveland, Ohio. Meets with American Railway Bridge and Building Association.

CANADIAN RAILWAY CLUB.—C. R. Crook, 2276 Wilson Ave., N. D. G., Montreal, Que. Regular meetings, second Monday of each month, except June, July, and August, Windsor Hotel, Montreal, Que.

CAR DEPARTMENT OFFICERS' ASSOCIATION.—A. S. Sternberg, M. C. B. Belt Ry. of Chicago, 7926 South Morgan Street, Chicago.

CAR FOREMAN'S ASSOCIATION OF CHICAGO.—G. K. Oliver, 2514 W. 55th St., Chicago. Regular meetings, second Monday of each month, except June, July and August, Auditorium Hotel, Chicago.

CAR FOREMEN'S ASSOCIATION OF LOS ANGELES.—J. W. Krause, Room 299, 610 So. Main St., Los Angeles, Cal. Club not active at present time.

CAR FOREMEN'S ASSOCIATION OF ST. LOUIS, MO.—J. F. Brady, Main and Barton Sts., St. Louis, Mo. Operation suspended indefinitely.

CENTRAL RAILWAY CLUB OF BUFFALO.—M. D. Reed, 1817 Hotel Statler, McKinley Square, Buffalo, N. Y. Regular meetings, second Thursday of each month, except June, July and August, Hotel Statler, Buffalo, N. Y.

CINCINNATI RAILWAY CLUB.—D. R. Boyd, 2920 Utopia Place, Hyde Park, Cincinnati, Ohio. Operation suspended indefinitely.

CLEVELAND RAILWAY CLUB.—F. L. Frericks, 14416 Alder Ave., Cleveland, Ohio. Regular meetings second Monday of each month, except June, July and August, Hotel Cleveland, Cleveland, Ohio.

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION.—W. J. Mayer, Michigan Central R. R., Detroit, Mich.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.—T. D. Smith, 1660 Old Colony Building, Chicago, Ill.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION.—Wm. Hall, 1061 W. Wabasha St., Winona, Minn.

MASTER BOILER MAKERS' ASSOCIATION.—A. F. Stiglmeier, 29 Parkwood St., Albany, N. Y.

NATIONAL ASSOCIATION OF RAILROAD AND UTILITIES COMMISSIONERS.—James B. Walker, 270 Madison Ave., New York. Annual meeting, October 10-13, 1933, Hotel Gibson, Cincinnati, Ohio.

NATIONAL ASSOCIATION OF RAILROAD TIE PRODUCERS.—(See Railway Tie Association.).

NATIONAL RAILWAY APPLIANCES ASSOCIATION.—C. W. Kelly, Suite 322, 910 South Michigan Ave., Chicago. Exhibit at A. R. E. A. convention.

NATIONAL SAFETY COUNCIL.—Steam Railroad Section (See Safety Section, American Railway Association).

NEW ENGLAND RAILROAD CLUB.—W. E. Cade, Jr., 683 Atlantic Ave., Boston, Mass. Regular meetings, second Tuesday of each month, except June, July, August and September, Hotel Statler, Boston, Mass.

NEW YORK RAILROAD CLUB.—D. W. Pye, 30 Church St., New York. Regular meetings third Friday of each month, except June, July and August, 29 W. 39th St., New York City.

PACIFIC RAILWAY CLUB.—W. S. Wollner, P. O. Box 3275, San Francisco, Cal. Regular meetings second Thursday of each month, alternately in San Francisco and Oakland.

RAILWAY ACCOUNTING OFFICERS' ASSOCIATION.—E. R. Woodson, Transportation Building, Washington, D. C.

RAILWAY BUSINESS ASSOCIATION.—P. H. Middleton, (Treas. and Asst. Sec.), First National Bank Building, Chicago, Ill. Annual meeting, November, 1933, Hotel Stevens, Chicago, Ill.

RAILWAY CLUB OF PITTSBURGH.—J. D. Conway, 1841 Oliver Building, Pittsburgh, Pa. Regular meetings, fourth Thursday of each month except June, July and August, Fort Pitt Hotel, Pittsburgh, Pa.

RAILWAY ELECTRICAL SUPPLY MANUFACTURERS ASSOCIATION.—Edward Wray, 9 S. Clinton St., Chicago. Meets with Association of Railway Electrical Engineers.

RAILWAY FIRE PROTECTION ASSOCIATION.—R. R. Hackett, Baltimore & Ohio R. R., Baltimore, Md. Annual meeting, October 17-18, 1933, Hotel Stevens, Chicago, Ill.

RAILWAY SUPPLY MANUFACTURERS' ASSOCIATION.—J. D. Conway, 1841 Oliver Bldg., Pittsburgh, Pa. Meets with Mechanical Division Purchases and Stores Division and Motor Transport Division, American Railway Association.

RAILWAY TELEGRAPH AND TELEPHONE APPLIANCE ASSOCIATION.—G. A. Nelson, Waterbury Battery Company, 30 Church St., New York. Meets with Telegraph and Telephone Section of A. R. A. Division I.

RAILWAY TIE ASSOCIATION.—Roy M. Edmonds, 1252 Syndicate Trust Bldg., St. Louis. Mo.

RAILWAY TREASURY OFFICERS ASSOCIATION.—L. W. Cox, 1428 Broad Street Station Building, Philadelphia, Pa. Annual meeting, October 6-7, 1933, Chicago, Ill.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION.—T. F. Donahoe, Gen. Supvr. Road, Baltimore & Ohio, Pittsburgh, Pa. Annual meeting, September 19-21, 1933, Hotel Stevens, Chicago, Ill.

ST. LOUIS RAILWAY CLUB.—B. W. Frauenthal. Drawer 24, M. P. O., St. Louis, Mo. Meetings temporarily suspended.

SIGNAL APPLIANCE ASSOCIATION.—G. A. Nelson, Waterbury Battery Company, 30 Church St., New York. Meets with A. R. A. Signal Section.

SOCIETY OF OFFICERS, EASTERN ASSOCIATIONS OF RAILROAD VETERANS.—M. W. Jones, Baltimore & Ohio, Mt. Royal Station, Baltimore, Md. Annual meeting, October 7-8, 1933, Scranton, Pa.

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.—A. T. Miller, 4 Hunter St., S. E., Atlanta, Ga. Regular meetings, third Thursday in January, March, May, July, September and November, Ansley Hotel, Atlanta, Ga.

SOUTHERN ASSOCIATION OF CAR SERVICE OFFICERS.—R. G. Parks, A. B. & C. R. R., Atlanta, Ga.

SUPPLY MEN'S ASSOCIATION.—E. H. Hancock, Treasurer, Louisville Varnish Co., Louisville, Ky. Meets with A. R. A. Division V. Equipment Painting Section.

TOOL FOREMEN SUPPLIERS' ASSOCIATION.—E. E. Caswell, Union Twist Drill Co., 11 S. Clinton St., Chicago, Ill. Meets with American Railway Tool Foremen's Association.

TORONTO RAILWAY CLUB.—N. A. Walford, P. O. Box 8, Terminal "A." Toronto. Regular meetings first Friday of each month, except June, July and August, Royal York Hotel, Toronto, Ont.

TRACK SUPPLY ASSOCIATION.—L. C. Ryan, Oxweld Railroad Service Co., Carbon & Carbide Building, Chicago. Meets with Roadmasters and Maintenance of Way Association.

TRAVELING ENGINEERS' ASSOCIATION.—W. O. Thompson, 1177 East 98th St., Cleveland, O.

WESTERN RAILWAY CLUB.—C. L. Emerson, C. M. St. P. & P., Chicago, Ill. Regular meetings third Monday of each month, except June, July, August and September, Hotel Sherman, Chicago, Ill.

Equipment and Supplies

LOCOMOTIVES

THE DURHAM & SOUTHERN has ordered one 2-10-0 type locomotive from the Baldwin Locomotive Works.

THE UNITED FRUIT COMPANY has ordered two 2-8-2 type locomotives from the Baldwin Locomotive Works.

THE UNITED STATES NAVY DEPARTMENT has ordered two Diesel-electric switching locomotives of 35-tons' capacity from the Atlas Car & Manufacturing Company. Inquiry for this equipment was reported in the *Railway Age* of March 18.

FREIGHT CARS

THE NATIONAL REFINING COMPANY has ordered 10 tanks of 8,000 gal. capacity, for tank cars, from the General American Car Company.

THE UNITED STATES ENGINEERS, New Orleans, La., are inquiring for four electrically driven asphalt cars of 20 tons' capacity.

THE PHILIPPINE RAILWAY has ordered 35 cane cars from the Magor Car Corporation, 10 cars to be of 30 tons' capacity and 25 of 10 tons. Inquiry for this equipment was reported in the *Railway Age* of June 3.

PASSENGER CARS

THE NEW YORK RAPID TRANSIT COMPANY (B. M. T.) has ordered from the Pullman Car & Manufacturing Corporation one multi-section, aluminum alloy, articulated 5-car train, for service on its elevated and subway lines.

PENNSYLVANIA—All passenger trains in the New York-Philadelphia service of this road are to be made up with air-conditioned coaches, parlor cars and diners as early as possible. Its Altoona works has already started assembling the necessary materials, and the Pullman Company has begun to equip in a similar manner the necessary additional parlor-lounge cars and parlor cars for this particular service. Air-conditioned equipment is already in operation on all the New York-Philadelphia-Washington trains of P.R.R. and when the additional cars for the New York-Philadelphia service are in use, this road will have in operation on its eastern lines over 200 cars in which the temperature is regulated by artificial means. For over a year air-cooled diners have been operated on all the limited trains between New York, Philadelphia, Chicago, Pitttsburgh, St. Louis and Washington.

MOTOR COACHES

THE NEW ENGLAND TRANSPORTATION COMPANY has purchased from the American Car & Foundry Motors Company eight 21-passenger parlor type buses which will be assigned to express service on the route between New York and Springfield, Mass.

IRON AND STEEL

THE SOUTHERN PACIFIC is inquiring for 1,000 tons of structural steel for a passenger station at Houston, Tex.

THE SOUTHERN has placed an order for 1,150 tons of 100-lb. R. E. rail with the Tennessee Coal, Iron & Railroad Company.

THE ST. LOUIS-SAN FRANCISCO has ordered 4,300 tons of rails from the Tennessee Coal, Iron & Railroad Company.

MISCELLANEOUS

THE CHICAGO, ROCK ISLAND & PACIFIC Silvis shops, closed since March 10, will reopen on July 5, giving employment to 750 men.

THE PENNSYLVANIA, in view of increased traffic, and to meet present and prospective needs of the service, will place in effect during July an augmented program of maintenance and repairs of both track and equipment. This will give additional work during the month to a number of men now on part time. In the maintenance of way work, the chief additional activities will be concentrated on ballast cleaning, including the surface of the track, and increased renewals of rails and ties. The maintenance of equipment department activities will principally be increased repairs to locomotives and cars, and installation of air-conditioning apparatus in passenger cars.

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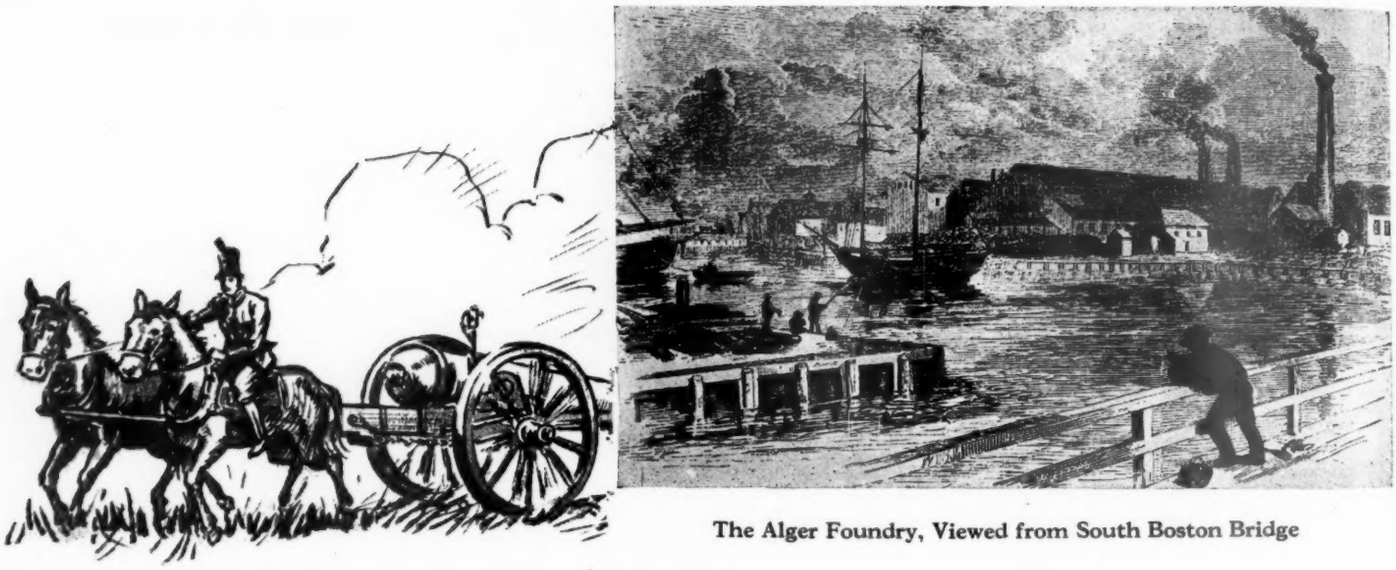


The Alger Foundry, Viewed from South Boston Bridge

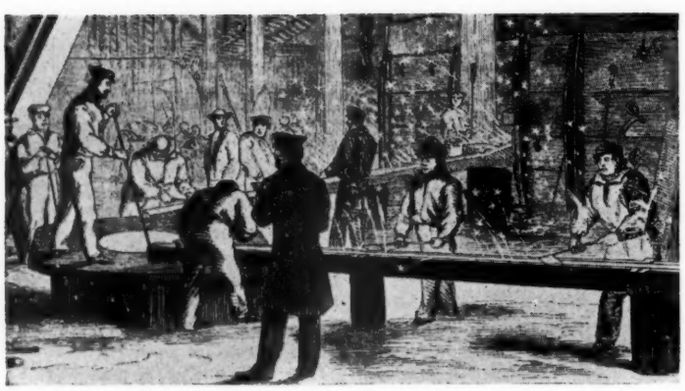
BEFORE THE "IRON HORSE"

RESEARCH IN THE SCIENCE OF METALLURGY PRODUCED AMERICA'S FAMOUS GUN IRON

IN 1810, almost 20 years before the "Stourbridge Lion" arrived in America, Cyrus Alger, son of a foundryman, took up his father's trade, improved manufacturing methods and produced a metal several times the strength of ordinary iron.

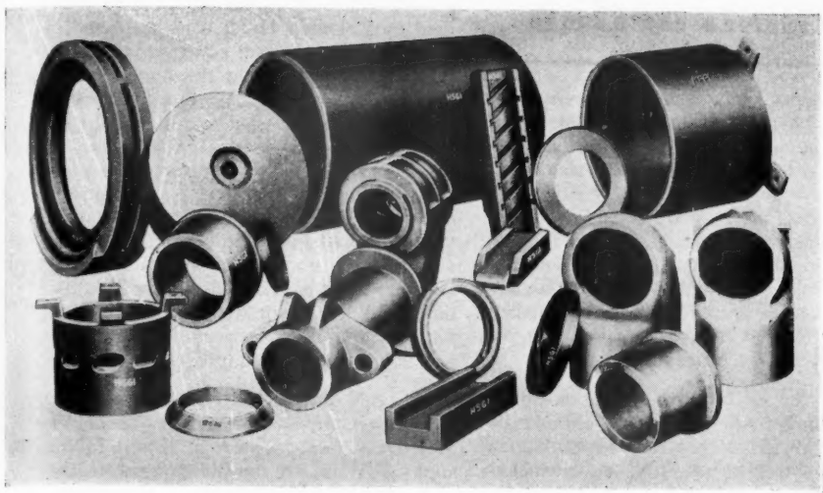
It was a sensational achievement—American ingenuity had developed a metal of tremendous value in the manufacture of cannon and heavy artillery. Mr. Alger's discovery of the ***Air Furnace*** method produced the metallurgical term "GUN IRON".

Improvement and progress were constant—the initiative of Cyrus Alger became a treasured heritage, passed down to the succeeding organizations and is zealously followed to the present day.

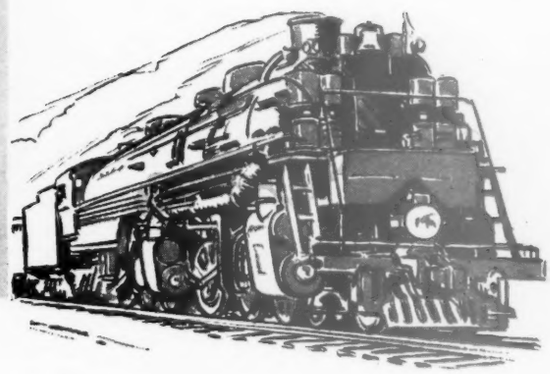


Casting Guns at the Alger Foundry

HUNT-SPILLER *Air*



HSG I Locomotive Wearing Parts



HSGI A VITAL MATERIAL

DEVELOPMENT OF SUPER WEARING QUALITIES A BIG FACTOR IN THE EFFICIENCY OF MODERN POWER

FROM big guns to the wearing parts of big locomotives is a long story replete with industrial romance and scientific achievement.

Research—diligent co-operation with industry and continuous improvement in quality has produced a metal which is recognized by American railroads to be one of the greatest factors contributing to the efficiency and economy of operation.

Today, HUNT-SPILLER *Air Furnace* GUN IRON will be found on the locomotives of most all the leading railroads in North America. The economies effected are so attractive, that its use and scope of application are constantly being extended.

The more completely equipped, the greater your savings.

HUNT-SPILLER MFG. CORPORATION
J.G. Platt, Pres. & Gen. Mgr. V.W. Ellet, Vice-President.

Office & Works
383 Dorchester Ave. South Boston, 27, Mass.
Canadian Representative: Joseph Robb & Co., Ltd., 997 Aqueduct St., Montreal, P. Q.
Export Agent for Latin America:
International Rwy. Supply Co., 30 Church Street, New York, N. Y.

HUNT - SPILLER *Duplex* Sectional Packing for Locomotive Cylinders. Big Savings In Fuel and Maintenance Are Being Effected by its Application.

HUNT - SPILLER *Duplex* Sectional Packing for Locomotive Valve Chambers. One of the Latest Contributions to Economical Maintenance of Power.

Furnace **GUN IRON**

Supply Trade

The Railway Paint Company, Chicago, has moved its offices from the Lytton building to 75 East Wacker drive.

The Roller-Smith Company, New York, has appointed **H. R. Houghton** district sales agent for Maryland, with headquarters at 211 North Calvert street, Baltimore, Md.

George W. Bender has been appointed sales representative of the **Union Railway Equipment Company,** Chicago, in charge of its northwest territory, with headquarters at St. Paul, Minn. Through a typographical error, the name of this company was given as the Union Railway Company in the *Railway Age* of June 24.

T. F. Thornton has been appointed sales manager of the Detroit district, for the **Babcock & Wilcox Tube Company,** Beaver Falls, Pa. Mr. Thornton will have his headquarters in the Ford building, Detroit, Mich. For many years, he has been connected with the automotive and steel industries, and for the past six years has had charge of the sale of tubular products of the Pittsburgh Steel Company, in the Detroit district.

At a meeting of the board of directors on June 26, **W. J. Harris** was elected a vice-president of the **American Car & Foundry Company,** New York. Mr. Harris will continue in charge of the purchase section of the A. C. F., which position he has held since his transfer to New York from Berwick, Pa., in April, 1920. In 1889, he entered the service of the Jackson & Woodin Manufacturing Company, this being one of the 13 original manufacturing companies from which the American Car & Foundry Company was formed in 1899.

W. J. Harris

OBITUARY

William A. Williams, an assistant vice-president in the sales department of the American Car & Foundry Company at New York, with which company he had been associated since its organization in 1899, died on June 27 at the New York Post Graduate Hospital, New York, at the age of 64.

Construction

CALIFORNIA & OREGON COAST.—This company has applied to the Interstate Commerce Commission for a certificate authorizing the construction of an extension of its line from Waters Creek, Ore., to Crescent City, Cal., 72 miles, proposing to obtain a loan from the Reconstruction Finance Corporation for the purpose. It now has a line from Grant's Pass, Ore., to Waters Creek. It has also filed an application with the R. F. C. for a ten-year loan of $5,718,565 for the purpose.

DELAWARE & HUDSON.—This company has awarded a contract for the elimination of the Main street crossing of its line in Unadilla, Otsego county, N. Y., at an approximate cost of $147,654 to the Bates & Rogers Construction Company, Cleveland, Ohio. Structural steel involved has been purchased from the Lackawanna Steel Construction Corporation, Buffalo, N. Y.

Financial

ATCHISON, TOPEKA & SANTA FE.—*Abandonment.*—The Interstate Commerce Commission has authorized this company to abandon a 19.5-mile branch line extending from Quenemo, Kans., to Osage City. Railway operating revenues of the line declined from $11,197 in 1928 to $4,545 in 1932, due to highway competition and the depression. Meantime the company has paid taxes averaging $13,343 annually.

CHICAGO UNION STATION.—*Tentative Valuation.*—Division 1 of the Interstate Commerce Commission has issued a tentative valuation report as of December 31, 1927, finding the final value for rate-making purposes of the property owned and used for common-carrier purposes to be $46,500,000 and that of the property used for such purposes to be $47,350,000. This includes $26,192,696 as the cost of reproduction less depreciation and $20,757,026 as present value of land. The original cost to date, not including lands, was found to be approximately $41,707,394 for property owned and used, but only $3,998,225 was included in the reproduction figure for interest during construction, whereas the recorded amount was $21,087,903, covering a considerable period during which work was delayed by the war and by labor troubles. The total recorded cost of construction, including lands, was $71,323,905. Part of the property is classified as non-carrier. The investment in road and equipment, including land, on date of valuation, was stated on the books as $95,211,045. With readjustments required by the accounting examination this would be reduced to $87,841,411, including $60,469,963 recorded money outlay, including $17,664,116 for interest during construction.

FONDA, JOHNSTOWN & GLOVERSVILLE.—*Salary of Trustee Fixed By I. C. C.*—The Interstate Commerce Commission has prescribed $7,500 as the maximum salary to be paid to J. Ledlie Hees, who has been appointed by the federal court as trustee for the property, following the filing of a reorganization petition. Mr. Hees addressed a letter to the commission asking that the salary be fixed at at least $15,000 a year, the amount he had formerly received as president, stating that his salary was voluntarily reduced to $10,800 in 1931 but that it ought to be restored in view of the fact that he was required to give a bond for $50,000 and that the duties would require his entire time. Under the law the salary may be fixed by the court subject to a maximum prescribed by the commission.

GREAT NORTHERN.—*Bond Plan in Effect.*—The company has announced that holders of over 80 per cent of St. Paul, Minneapolis & Manitoba consolidated bonds have consented to its plan for extending their maturity date from July 1, 1933, to July 1, 1943. The first National Bank of New York is purchasing the bonds of holders who fail to agree to the extention of the maturity date.

GULF, COLORADO & SANTA FE.—*Abandonment.*—This company has applied to the Interstate Commerce Commission for authority to abandon a branch line from Bragg, Tex., to Saratoga, 9.17 miles.

KANSAS CITY SOUTHERN.—*Omits Preferred Dividend.*—Directors of this company have omitted the quarterly dividend on its preferred stock due at this time. For the first quarter of the current year 50 cents per share was declared. Prior thereto the quarterly rate had been $1.

LONG ISLAND.—*Abandonment.*—This company has applied to the Interstate Commerce Commission for authority to abandon its line from Port Jefferson, N. Y., to Wading River, 11 miles.

NEW YORK, NEW HAVEN & HARTFORD.—*Authorized to Acquire Control of Line.*—The Interstate Commerce Commission has authorized this company to acquire control of the 1.9-mile line (with 1.2 miles of sidings) of the South Manchester R. R. in South Manchester, Conn., by purchase of its capital stock for $1 from Cheney Bros., Inc., silk manufacturers. The New Haven will in addition cancel a debt of $35,901 owed to it by the South Manchester. The New Haven estimates that it can operate the property for $8,812 annually, as compared with an average of $29,159 under independent operation.

OZARK & PHILPOTT VALLEY.—*R. F. C. Loan.*—This company has applied to the Reconstruction Finance Corporation for a loan of $75,000 to complete construction of a line in Franklin county, Ark.

TOLEDO & WESTERN.—*Abandonment.*—The Interstate Commerce Commission has authorized this company, operating an electric line hauling, principally, freight, to abandon that portion of its line from Allen Junction, Ohio, to Pioneer, 43.3 miles. Residents and business men along the line protested the proposed abandonment, but the company estimated that the operating deficit of this segment had varied between $28,000 and $84,000 each year for

the past five years. Taxes have, in the same period, fluctuated between $6,000 and $11,000. Abandonment is conditioned upon the willingness of the company to sell all or any portion of the segment at salvage value to anyone who will keep it in operation. The Toledo & Western is controlled jointly by the Wabash and the Willys-Overland Company.

Average Prices of Stocks and of Bonds

	June 27	Last week	Last year
Average price of 20 representative railway stocks..	43.15	40.89	11.44
Average price of 20 representative railway bonds..	70.31	68.60	49.51

Valuation Reports

The Interstate Commerce Commission has issued final or tentative valuation reports finding the final value for rate-making purposes of the property owned and used for common-carrier purposes as of the respective valuation dates as follows:

Bonhomie & Hattiesburg Southern	$520,000 (final)	1928
Deep Creek	465,000 (final)	1927
Port Angeles Western	2,075,000 (final)	1927
East Texas & Gulf	48,000 (final)	1927
Chicago Union Station Co.	$46,500,000	1927
New Haven & Dunbar	Owned .... 204; Used 85,204	1927

Dividends Declared

Allegheny & Western.—$3.00, payable July 1 to holders of record June 20.

Clearfield & Mahoning.—$1.50, semi-annually, payable July 1 to holders of record June 20.

Cleveland, Cincinnati & St. Louis. — $5.00, semi-annually; 5 per cent preferred, $1.25, quarterly; both payable June 30 to holders of record June 21.

Connecticut & Passumpsic Rivers.—6 per cent preferred, $3.00, semi-annually, payable August 1 to holders of record July 1.

Kansas City Southern. — Preferred dividend omitted.

Lehigh & Hudson River.—$1.00, quarterly, payable June 30 to holders of record June 13.

Massawippie Valley.—$3.00, semi-annually, payable August 1 to holders of record July 1.

Norfolk & Western.—Common, $2.00, quarterly, payable September 19 to holders of record August 31; adjustment preferred, $1.00, quarterly, payable August 19 to holders of record July 31.

Northern Central.—$2.00, semi-annually, payable July 15 to holders of record June 30.

Paterson & Hudson River.—$1.75, semi-annually, payable July 1.

Philadelphia & Trenton.—$2.50, quarterly, payable July 10 to holders of record July 1.

Providence & Worcester.—$2.50, payable July 1 to holders of record June 14.

Reading Company.—Common, 25 cents, quarterly, payable August 10 to holders of record July 13; first preferred, 50 cents, quarterly, payable September 14 to holders of record August 24; second preferred, 50 cents, quarterly, payable October 12 to holders of record September 21.

Rome & Clinton.—$2.75, semi-annually, payable July 1 to holders of record June 21.

Railway Officers

FINANCIAL, LEGAL AND ACCOUNTING

D. D. Weikert, chief clerk to the secretary of the Reading, has been appointed assistant secretary.

OPERATING

A. R. McLeod has been appointed assistant superintendent of the Laurentian division of the Canadian Pacific, succeeding **W. C. Beck,** promoted.

Norman McMillan, superintendent of the Bruce division of the Canadian Pacific at Toronto, Ont., has been appointed assistant to the general manager, eastern lines. **B. J. Quilty,** superintendent of the Trenton division has been transferred to the Bruce division.

C. C. McHugh, a trainmaster on the Chicago, Rock Island & Pacific, with headquarters at Trenton, Mo., has been appointed acting superintendent of the Cedar Rapids-Dakota division, with headquarters at Cedar Rapids, Iowa, to succeed **A. L. Haldeman,** who has been granted a leave of absence because of illness.

Paul W. Johnston, assistant superintendent of transportation of the Erie, who has been promoted to superintendent of transportation, with headquarters as before at Cleveland, Ohio, was born on July 5, 1892, at Transfer, Pa. He received his higher education at Allegheny College, Meadville, Pa., and first entered the service of the Erie on July 1, 1909, serving as a clerk and agent at various points during his school vacations. In 1918 he was appointed station supervisor with headquarters at Meadville, and in the following

Paul W. Johnston

year he was further promoted to rules examiner with the same headquarters. In 1920, Mr. Johnston was advanced to supervisor of station service, with headquarters at Hornell, N. Y., being appointed trainmaster at Elmira, N. Y., in 1921. He was transferred to Hornell a year later, and in 1923 he was appointed chief clerk to the superintendent at Meadville. Four years later Mr. Johnston was again appointed trainmaster with the same headquarters, which position he held until 1929, when he was promoted to assistant superintendent of transportation, in which capacity he remained until his recent promotion to superintendent of transportation.

P. S. Lewis, assistant to vice-president in charge of operation and maintenance of the Reading, has been appointed general superintendent succeeding **V. B. Fisher,** who has been granted leave of absence. **W. W. Rhoads,** chief clerk to vice-president in charge of operation and maintenance, has been appointed assistant to vice-president, succeeding Mr. Lewis. **George N. Ewing,** assistant superintendent of the Philadelphia division, has been appointed superintendent to succeed **J. C. Peters,** who has been appointed special representative of the operating and traffic departments. **N. N. Baily,** for-

P. S. Lewis

merly assistant trainmaster, Reading division, has been appointed assistant superintendent of the Philadelphia division. Mr. Lewis, whose early years on the Reading were in the engineering and maintenance of way departments, was born on May 10, 1889, at Springfield, Ill., and attended Princeton University. He entered the service of the Reading in July, 1911, and after holding various positions in the engineering and maintenance of way departments, and seeing extended service in the engineering corps of the United States Army during the World War, he returned to the Reading as a trainmaster. Later he held the position of superintendent at several points and in December, 1932, he was appointed assistant to vice-president in charge of operation. A complete sketch of Mr. Lewis' career appeared in *Railway Age* of October 8, 1932, page 519.

Mr. Fisher, formerly general superintendent, was born on July 8, 1867, and entered the service of the Reading on April 1, 1882, as messenger, and on December 6, 1890, was appointed train dispatcher on the Shamokin division. Seven years later Mr. Fisher was appointed assistant trainmaster and on February 1, 1913, he became trainmaster. On January 30, 1918, he was appointed superintendent of the Shamokin division and on July 8, 1920, he was advanced to general superintendent of the system.

Mr. Rhoads, who was born on November 15, 1889, entered the service of the Reading on September 26, 1906, as a messenger at the Port Richmond terminal. A year later he was transferred as clerk into the transportation department, and on January 16, 1915, he was transferred as clerk to the office of vice-president and general manager. A year later he was transferred in the same capacity to the general manager's office. On December 1, 1917, he was appointed clerk in the vice-president's office, and on June 15, 1918, Mr. Rhoads was appointed secretary to the federal manager. On March 1, 1920, he became secretary to the vice-president, and on February 1, 1924, he was promoted to assistant chief clerk in the office of the vice-president. Mr. Rhoads became chief clerk to the vice-

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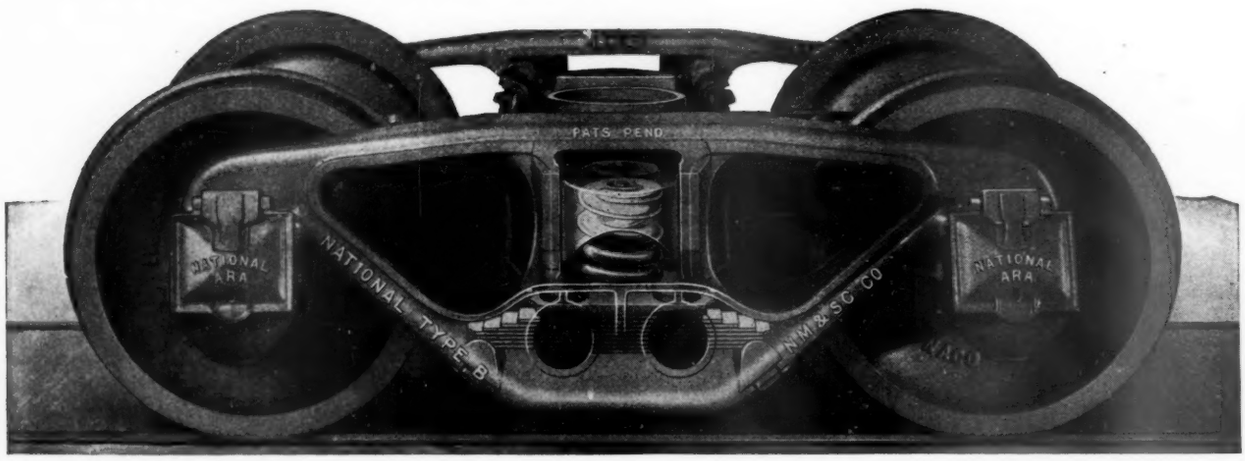
EFFICIENCY wi

IN OPERATION

RESEARCH and Development Work carried on through fifty years of manufacturing railroad equipment has enabled this company to offer many new and improved devices for the more efficient and economical operation and maintenance of the railway systems throughout the world.

Our laboratories have also developed through special treatment, materials having strength and wearing qualities far in excess of those normally found in the material.

A recent improvement in railroad equipment which has many important advantages is the National Type "B" Truck.



Advantageous Features of Type "B" Trucks

No Spring Plank	Increased Spring Capacity	More Flexible
Lighter and Stronger	Improved Brake Rigging	Fewer Parts
More Revenue Load	Safety Devices Cast Integral	No Lost Springs
More Track Clearance	Less Frame and Bolster Wear	Lateral Motion
Springs cannot go solid	Journal Box Water Ledge	Easier Riding
Longer Spring Life	Quick Wheel Change	No increase in cost

All-Coil and "Coil-Elliptic" Spring Suspensions are interchangeable in Type "B" Trucks, without reduction of side clearance.

Treatise No. 5133 explaining these advantages will be mailed upon request

NATIONAL MALLEABLE AND STEEL CASTINGS CO.
General Offices: CLEVELAND, OHIO

TH ECONOMY IN MAINTENANCE

PROTECTION of both cars and lading against the damaging shocks to which they are subjected in the handling of heavy trains, has long been one of the chief problems of transportation by rail.

Nearly a score of years of experimental work and service tests, to develop a smoothly working friction draft gear capable of cushioning both light and heavy shocks, yet rugged enough to withstand extreme oversolid blows, have resulted in the production of the

NATIONAL M-17-A DRAFT GEAR.

For the satisfactory performance of these gears, the American Railroad Association, Division 5, Mechanical, has issued to this company their Certificate of Approval.

The National M-17-A Draft Gear stands high in the combination of Capacity, Sturdiness and Endurance. It absorbs the shocks with a smoothness of action that affords the utmost protection to lading, and prolongs the life of both car and draft gear.

Write for Circular No. 1932

NATIONAL MALLEABLE AND STEEL CASTINGS CO.
General Offices: CLEVELAND, OHIO

president on May 1, 1929, which position he has held until his recent appointment as assistant to vice-president.

William W. Rhoads

Mr. Ewing was born on December 29, 1899, and received his education at William Penn Charter school and Lehigh University. He entered the service of the Reading in February, 1923, as assistant supervisor at Tamaqua. In April, 1925, he was appointed mechanical supervisor at

George N. Ewing

Philadelphia and in January, 1926, he became assistant to trainmaster. In March, 1927, Mr. Ewing was appointed acting assistant trainmaster at Wayne Junction. In April, 1928, he became assistant trainmaster at Wayne Junction and two years later was promoted to assistant trainmaster on the New York division. On September 1, 1931, Mr. Ewing was appointed assistant superintendent, New York division, and a year later he became assistant superintendent of the Philadelphia division.

ENGINEERING AND SIGNALING

Edward Wise, Jr., who has been engineer in charge of the Birmingham, Ala., grade separation project of the Louisville & Nashville, has been appointed to the newly-created position of division engineer of the Pensacola division, with headquarters at Pensacola, Fla.

F. J. Bishop, engineer of bridges, buildings and signals of the Toledo Terminal, at Toledo, Ohio, has been appointed engineer maintenance of way to succeed **Ray Stephens,** who has been assigned to other duties. The position of engineer bridges, buildings and signals has been abolished.

Following a consolidation of divisions on the Michigan Central in which the Northern division, with the exception of the Rives Jct.-Bay City branch, was merged with the Detroit division, and the Middle division and the Rives Jct.-Bay City branch were consolidated to form the Michigan division, a number of changes among division engineers have been made. **John Evans** remains as division engineer of the enlarged Detroit division, with headquarters as before at Detroit. **W. O. Houston,** division engineer of the Middle division, has been appointed to the same position on the new Michigan division, with headquarters as before at Jackson, Mich. **S. D. Williams, Jr.,** division engineer of the Northern division, with headquarters at Bay City, Mich., has been appointed to the newly-created position of engineer of track, with headquarters at Detroit. **E. R. Lewis,** principal assistant engineer, has been appointed office engineer with headquarters as before at Detroit.

MECHANICAL

Theodore A. Foque, who retired as general mechanical superintendent of the Minneapolis, St. Paul & Sault Ste. Marie, on July 1, as noted in the *Railway Age* of June 24, was born on January 14, 1866, at Boston, Mass., and received his technical education at Massachusetts Institute of Technology. He entered railway service in 1888 as chief draftsman and engineer of tests of the Soo Line and has served continuously with this company ever since. In 1894 he was advanced to assistant mechanical superintendent and in 1901 he was made mechanical superintendent, being advanced to general mechanical superin-

Theodore A. Foque

tendent in 1909, which position he held continuously until his retirement. During federal control of the railroads, Mr. Foque's jurisdiction as general mechanical superintendent of the Soo Line was extended over the Duluth, South Shore & Atlantic, the Mineral Range Railroad, the Copper Range Railroad and the Lake Superior Terminal & Transfer Company, and upon the return of the railroads to private control, he retained jurisdiction of the D. S. S. & A. and the Mineral Range.

OBITUARY

W. H. Olin, supervisor of agriculture of the Denver & Rio Grande Western, with headquarters at Denver, Colo., died suddenly on June 21 at the age of 71 years.

R. Boone Abbott, assistant general superintendent of the Reading, with headquarters at Reading, Pa., died at his home at Reading on June 25. Mr. Abbott was to have been appointed superintendent of the Reading division, in connection with an announcement of changes among certain operating officers of the Reading, released on June 24. He was born at Philadelphia, Pa., on July 14, 1881. He entered railway service with the Philadelphia & Reading on October 1, 1900, and in December of the same year was appointed assistant supervisor at Tamaqua. In 1905, he was transferred to Reading and two months later to Harrisburg. On June 6, 1905, he was promoted to supervisor at Allentown, Pa., later serving in the same capacity at Olney, Philadelphia and Pottsville, Pa. He was promoted to division engineer at Harrisburg, Pa., in March, 1910, in which capacity he served until March, 1916, when he was promoted to superintendent of the Shamokin division, later in the same month being transferred to the Harrisburg division, with headquarters at Harrisburg. In August, 1918, Mr. Abbott was appointed superintendent of the New York division, and on March 1, 1920, was promoted to assistant general superintendent, which position he was holding at the time of his death.

David Sloan, formerly chief engineer of the Illinois Central, died on June 25, at Wilmette, Ill., a suburb of Chicago, at the age of 85 years. Mr. Sloan was born on July 4, 1847, at Belfast, Ireland, and entered railway service in 1871 as a chainman on construction with the Lake Shore & Michigan Southern (now part of the New York Central). In 1874 he went with the Eastern Kentucky (now the Eastern Kentucky Southern) as assistant engineer at Grayson, Ky., and after three years with this company he returned to the L. S. & M. S., on harbor work at Ashtabula, Ohio. From 1883 to 1887 he was with the Chicago & Atlantic (now part of the Erie), serving as chief engineer during the last two years of this period. In the latter year Mr. Sloan went with the Chicago, Milwaukee & St. Paul as an assistant engineer, soon leaving this road to become assistant chief engineer of the Illinois Central. On August 1, 1897, he was advanced to acting chief engineer and in January, 1898, he was appointed chief engineer, which position he held until 1901, when he was appointed chief engineer of construction of the Illinois Central. In 1902 Mr. Sloan left railway service to become chief engineer with the MacArthur Brothers Company, general contractors at Chicago, later serving this company as consulting engineer. Since his retirement Mr. Sloan has made his home at Princeton, N. J.